C&D TECHNOLOGIES
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U.S. Nuclear Regulatory Commission
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May 21, 2014

Subject: Reply to Notice of Nonconformances (4) and Unresolved Item (1) Report No. 99901385/2014-201

Chief,

This letter and attachments is C&D Technologies' Response to the NRC inspection at C&D's Blue Bell, Pennsylvania location from March 3 to March 7, 2014 and the resultant NRC report of the inspection, dated April 21, 2014.

Per the instructions in Report 99901385/2014-201 the Notice of C&D's root cause determinations and corrective actions both completed and planned are in the attached C&D RS-1037 Corrective Action Forms (CAR). For those corrective actions that have been completed, selected verification documentation is also attached.

NRC Reference	C&D Reference	Additional Documentation
99901385/2014-201-01	RS-1037 14-14	None
99901385/2014-201-02	RS-1037 14-15	Qualification Report QR2-07209
99901385/2014-201-03	RS-1037 14-16	IEEE Code Review for Nuclear Qualification
99901385/2014-201-04	RS-1037 14-17	None
99901385/2014-201-05	RS-1037 14-18	None

C&D is committed to correcting the identified issues and believe the actions both planned and implemented will prevent recurrence of the issues identified by the NRC.

Please contact me if you have any questions or would like additional information.

Sincerely,

Steven T. DiMauro

Steve DiMauro
Quality Systems Manager
1400 Union Meeting Road
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484-294-6410

IE09
NRO

Cc: Chief, Construction Electrical Vendor Branch,
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C. Rheault, President and CEO
J. Miller, VP Operations
D. Anderson, VP General Counsel
R. Malley, VP Quality and Process Engineering
J. Anderson, VP, New Technology and Battery Design
D. Heimer, Director Product Development
L. Carson, Nuclear Product Manager

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Corrective / Preventive Action

Type of Action: Corrective Action	**Source of Action:** NRC Inspection – March, 2014 **Type of Request**: NRC Inspection 99901385/2014-201

Corrective Action:RS-1037 14-14 Date Issued: April 23, 2014 Date parts B-D Due: **5-23-14**

To: Steve DiMauro, RS-1037 14-14, URI 99901385/2014-201-01 From: Steve DiMauro

A) **Deficiency/Non Conformity**: Describe in detail the nature of the problem, list the facts, and indicate any applicable documents. Note: include checksheet question #s - for standard references refer to the internal audit checksheet. If multifaceted with multiple assignees, identify specific assignee for each nonconformance.

Descriptive Title – Part 21 Unanalyzed Deviations

The NRC identified that in evaluation report number, 2012-12, for Entergy (Palisades Nuclear Power Plant), C&D failed to prepare and submit an interim report for an identified deviation potentially associated with a substantial safety hazard (SSH) that could not be completed within 60 days of discovery. C&D was notified of a deviation with misaligned separators on LCR-25 battery cells on February 16, 2012, entered a Part 21 evaluation on February 26, 2012, and closed the evaluation on March 5, 2012, documenting it was not a defect. However, on March 6, 2012, C&D informed the customer that they did not meet specifications regarding the amount that the separators overlap the edges of the plates and that a current path between two adjacent plates can develop leading to discharged cells. Specifically, C&D noted they could not determine the root cause, or if/when this issue would occur, until they received the batteries back from the customer. Based on this inspection, C&D reopened a Part 21 evaluation and submitted an interim report to the NRC to address this deficiency on March 28, 2014 (Agencywide Document Access and Management System (ADAMS) Accession Number ML14094A012). In addition, C&D failed to evaluate deviations documented in the following customer complaints to identify defects and failures to comply associated with SSHs as soon as practicable:

- COMP-2012-00163, dated August 31, 2012 - Exelon (Clinton Power Station) informed C&D that lead flake/slag deposits were unacceptable and could become shortening risks. C&D marked this COMP as not requiring a Part 21 evaluation despite noting in the COMP that the lead rundowns present a risk in that they may cause shorts at some point if the lead rundowns and balled lead separate from the straps.
- COMP-2012-00007, dated January 10, 2012 - South Carolina Electric & Gas (SCE&G) (Virgil C. Summer Nuclear Station) identified foreign material on a cell of a new battery that was suspected to be lead rundowns. C&D noted that lead rundown will not have an impact on performance at the current location, but the pieces could move and come into contact with two adjacent plates. C&D recommended that cell voltage be measured and visual inspections be conducted more frequently than normal and that the cell should be replaced at the next scheduled outage. C&D documented this COMP as not requiring a Part 21 evaluation in order to identify a reportable defect or failure to comply that could create a SSH, were this issue to remain uncorrected.
- COMP-2013-00040, dated February 7, 2013 - XCEL Energy (Monticello Nuclear Generating Plant) identified foreign material in the top of a battery cell. C&D provided a replacement battery, but documented this COMP as not requiring a Part 21 evaluation in order to identify a reportable defect or failure to comply that could create a SSH, were this issue to remain uncorrected.
- COMP-2013-00113, dated April 29, 2013 - PSEG (Salem Nuclear Generating Station) identified high sediment for a KCR-21 battery. Salem performed regular maintenance to assure there were no shortening of affected cells, and the cell was replaced; however, this COMP was documented as not requiring a Part 21 evaluation in order to identify a reportable defect or failure to comply that could

create a SSH, were this issue to remain uncorrected. Furthermore, the NRC inspectors identified additional departures from technical requirements included in procurement documents regarding battery qualification, documented in Section 2.b of this report, that were not identified as deviations nor evaluated to identify defects and failures to comply associated with SSHs; and specifically, if the batteries are qualified to perform their intended safety-function. In addition, the inspectors identified misused terms in C&D's Part 21 procedure, A-14, such as, "Once the Discovery has been identified to the Safety Committee; the Director of Quality shall (within five days of discovery) in conjunction with the Director of Product Development assess if the defect requires engineering evaluation and if this evaluation can be completed within 60 days." This is in conflict with A-14's definition of defect, "A deviation in a basic component delivered to a purchaser for use in a facility or an activity subject to the regulations in 10 CFR Part 21 if, on the basis of an evaluation, the deviation could create a substantial safety hazard."

Conclusions

The NRC inspection team concluded that the unanalyzed deviations involving misaligned separators, battery qualification, and lead slags/foreign material within the batteries, and C&D's failure to file an interim report in accordance with Part 21 timelines, are an unresolved item pending C&D's evaluation of theses deviations discussed in Section 1.b of the report details (Unresolved Item (URI) 99901385/2014-201-01).

B) **Containment**: response to contain the problem and prevent additional harm to customer from incident

1) As stated, an Interim Report for the Palisades issue identified above was issued on 3-28-2014. Part 21 evaluations are ongoing for all issues identified during the NRC Inspection.

C) **Determination of Root Cause**: Before resolution, root cause needs to be identified

1) Determinations were made on a case-by-case basis as to the need to generate Part 21 evaluations for situations which were detected during receipt and normal operating inspection activities. Personnel failed to formally initiate procedure A-14 for those cases.

D) **Corrective Action**: Indicate the resolution plan and controls to prevent recurrence with responsibilities and target dates assigned.

1) The corrective actions for all of the issues identified in this URI are being addressed in CARs generated for NRC Nonconformances 99901385/2014-201-03 and 99901385/2014-201-04. In addition, as stated in the response to 99901385/2014-201-04, regularly scheduled meetings are being conducted with Quality, Engineering, and Product Management to evaluate and document potential 10CFR, Part 21 concerns.
2) A review of all iSight cases from 2009 to the present will be conducted to determine if any other cases exist which could be unanalyzed deviations. The conclusion of the aforementioned analysis will be completed by September 30, 2014. Part 21 evaluations and applicable notifications will be conducted if any defect is identified.

Date Corrective Action Assigned: 5-19-2014 Signature of Manager: Steven T. DiMauro

E) **Verification**: Verification statement of the corrective action implementation

1)

Actual Completion Date: Verified by:

F) **Disposition**: Open

Closed by:

Date: Follow-up Date:

Y

Indicate if review for 10 CFR Part 21 applicability is required (ref: C&D Standard Policy & Procedure A-14): **Y** or **N**

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Corrective / Preventive Action

Type of Action: Corrective Action	**Source of Action:** NRC Inspection – March, 2014 **Type of Request**: NRC Inspection 99901385/2014-201

Corrective Action:RS-1037 14-15 Date Issued: April 23, 2014 Date parts B-D Due: **5-23-14**

To: Jon Anderson, RS-1037 14-15, 99901385/2014-201-02 From: Steve DiMauro

A) **Deficiency/Non Conformity**: Describe in detail the nature of the problem, list the facts, and indicate any applicable documents. Note: include checksheet question #s - for standard references refer to the internal audit checksheet. If multifaceted with multiple assignees, identify specific assignee for each nonconformance.

Descriptive Title – Design Control

Criterion III, "Design Control," of Appendix B to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 states, in part, that "Where a test program is used to verify the adequacy of a specific design feature in lieu of other verifying or checking processes, it shall include suitable qualifications testing of a prototype unit under the most adverse design conditions." Section 8.2, "Aging Procedure," states, in part, that naturally aged cells [operated cells] may be used for qualification testing or accelerated aging of the entire cell [by procedure].

Contrary to the above, C&D failed to provide documentation to show that the LCR-21 batteries on customer order 2393760 were qualified under the most adverse conditions in accordance with purchase order (PO) specification IEEE 535-1979. Specifically, C&D referenced a previous type testing report to bound battery qualification for this customer order; however, the referenced qualification report was not performed in accordance with IEEE 535-1979 with respect to properly aging the batteries to provide assurance that the batteries are capable of performing before, during, and after a seismic event.

B) **Containment**: response to contain the problem and prevent additional harm to customer from incident

1) None with the exception of generation of this CAR.

C) **Determination of Root Cause**: Before resolution, root cause needs to be identified

1) The Qualification Report (QR 207209) referenced in customer order 2393760 erroneously is missing the reference to aging duration of the LC-21 cell type in Table 2 on page 8, however on Page 25 of the report, paragraph 2, the report clearly states that " . . . Nuclear Environmental Qualification Report No. QR-1-72042, dated 7 Feb 83,and already in your possession, shows that LC cells thermally aged per the requirements of IEEE-535-1979 to an equivalent life of 20 years of normal service, are capable of exceeding the environmental requirements of the Arkansas Nuclear One Power Plant."

   The format of the report with relevant information scattered in various sections can make it difficult to draw conclusions regarding product qualification and engineering bounding.

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Corrective / Preventive Action

D) **Corrective Action**: Indicate the resolution plan and controls to prevent recurrence with responsibilities and target dates assigned.

1) C&D Engineering completed a review of Qualification Report QR2-07209 and determined that no issues exist which would compromise the seismic qualification of the LC-21 batteries. However, Engineering will conduct an evaluation of applicable documents and create a cross-reference document which corrects any unclear references and clearly explains the conclusion of the acceptability of the qualification testing for the LCR-21 batteries. This action should be completed by August 31, 2014.

Date Corrective Action Assigned: 5-19-2014 Signature of Manager: Steven T. DiMauro

E) **Verification**: Verification statement of the corrective action implementation

1)

Actual Completion Date: Verified by:

F) **Disposition**: Open

Closed by:

Date: Follow-up Date:

Y Indicate if review for 10 CFR Part 21 applicability is required (ref: C&D Standard Policy & Procedure A-14): **Y** or **N**

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Corrective / Preventive Action

Type of Action:	**Source of Action:** NRC Inspection – March, 2014
Corrective Action	**Type of Request:** NRC Inspection 99901385/2014-201

Corrective Action:RS-1037 14-16 Date Issued: April 23, 2014 Date parts B-D Due: **5-23-14**

To: Jon Anderson, RS-1037 14-16, 99901385/2014-201-03 From: Steve DiMauro

A) **Deficiency/Non Conformity**: Describe in detail the nature of the problem, list the facts, and indicate any applicable documents. Note: include checksheet question #s - for standard references refer to the internal audit checksheet. If multifaceted with multiple assignees, identify specific assignee for each nonconformance.

Descriptive Title – Design Control

Criterion III, "Design Control," of Appendix B to 10 CFR Part 50 states, in part, that, measures should be established to assure that "...appropriate quality standards are specified and included in design documents and that deviations from such standards are controlled. Measures shall also be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety-related functions of the structures, systems and components." Contrary to the above, C&D failed to take measures to review for suitability that ensures that original type testing performed for K-line batteries envelop customer qualification requirements.

C&D's failure to adequately demonstrate that original type testing performed for K-line batteries envelop current customer qualification requirements is documented by the following examples:

- PO 00472405 from Exelon (Braidwood Station and Byron Station) required batteries to be qualified to IEEE 535-2006, IEEE 344-2004, and IEEE 450-2002. C&D created a qualification report to show how batteries supplied by PO 00472405 were bounded by the original K-line batteries type testing that was performed in 1977, that utilized IEEE 535 draft version 8, IEEE 344-1975, and IEEE 450-1975. However, C&D failed to provide any documentation to show how the differences between the IEEE versions required by the PO and original K-type testing were evaluated and/or dispositioned with the customer within the qualification report.
- C&D failed to provide documentation to show a qualification report existed for PO 00501212, Revision 3, to Exelon (Clinton Power Station). Specifically, C&D failed to provide documentation to show that batteries supplied via this PO are qualified and bounded to the original type testing document.

B) **Containment**: response to contain the problem and prevent additional harm to customer from incident

1) None with the exception of generation of this CAR.

C) **Determination of Root Cause**: Before resolution, root cause needs to be identified

1) Because of the age of the qualification report (published in 1984) for PO 00501212, C&D was not able to locate it at the time of the NRC Inspection. Since that time, the qualification report has been located.

2) Through our leadership and participation in the IEEE Working Group that developed IEEE 535, C&D was aware of the changes to the applicable standards, but because the changes to the standards did not impact the qualification report it had not been updated to reflect those changes.

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Corrective / Preventive Action

D) **Corrective Action**: Indicate the resolution plan and controls to prevent recurrence with responsibilities and target dates assigned.

1) C&D Engineering developed a formal cross-reference document which bridges the various standard revisions and the original K-type testing with regards to customer requirements. The document shows that the changes to the applicable IEEE standards had no impact on the qualification of the batteries. This cross-reference document will be updated as changes to the applicable standards are revised. The result of the review determined that C&D is compliant to all of the relevant standards.

2) A procedure will be developed to ensure that as the applicable IEEE standards are revised, the qualification is reviewed and the cross-reference document updated to reflect that review. This action should be completed by 7-31-2014.

Date Corrective Action Assigned: 5-19-2014 Signature of Manager: Steven T. DiMauro

E) **Verification**: Verification statement of the corrective action implementation

1)

Actual Completion Date: Verified by:

F) **Disposition**: Open

Closed by:

Date: Follow-up Date:

Y Indicate if review for 10 CFR Part 21 applicability is required (ref: C&D Standard Policy & Procedure A-14): **Y** or **N**

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Corrective / Preventive Action

Type of Action:	**Source of Action:** NRC Inspection – March, 2014
Corrective Action	**Type of Request**: NRC Inspection 99901385/2014-201

Corrective Action:RS-1037 14-17 Date Issued: April 23, 2014 Date parts B-D Due: **5-23-14**

To: Steve DiMauro, RS-1037 14-17, 99901385/2014-201-04 From: Steve DiMauro

A) **Deficiency/Non Conformity**: Describe in detail the nature of the problem, list the facts, and indicate any applicable documents. Note: include checksheet question #s - for standard references refer to the internal audit checksheet. If multifaceted with multiple assignees, identify specific assignee for each nonconformance.

Descriptive Title – Corrective Action

Criterion XVI, "Corrective Action," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," states that "Measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances are promptly identified and corrected. In the case of significant conditions adverse to quality, the measures shall assure that the cause of the condition is determined and corrective action taken to preclude repetition. The identification of the significant condition adverse to quality, the cause of the condition, and the corrective action taken shall be documented and reported to appropriate levels of management." BB-QOP 8.5.2, Corrective Action, dated May 11, 2011, states, in part, that the purpose of this procedure is to define the corrective action requirements to assure that measures are established to assure that conditions adverse to quality are promptly identified and corrected.

Contrary to the above, as of March 3, 2014, C&D failed to assure conditions adverse to quality are identified and corrected.

C&D's corrective action program failure is documented by the following examples:

- The NRC inspection team found that the corrective actions (CA) generated to address previous violations and nonconformances identified in NRC inspection report 99901385/2009-201 were insufficient to correct the identified problems. Specifically, C&D CA report 09-049 and 09-050 were initiated to resolve violations 99901385/2009-201-01 and 99901385/2009-201-02. Violation 99901385/2009-201-01 was cited for an inadequate procedure due to the failure to adequately prescribe the process to perform an evaluation and meet timeliness requirements as specified in Part 21. The first example of Violation 99901385/2009-201-02 was cited due to the failure to perform an evaluation within the time requirements specified in Part 21. The second example of Violation 99901385/2009-201-02 was cited due to failure to perform an evaluation. During this inspection, the NRC inspectors found multiple examples where 10 CFR Part 21 evaluations were not being completed for deviations; that C&D did not file an interim report in accordance with Part 21 timelines; and, misuse of Part 21 terms within the Part 21 procedure. Based on these examples, the NRC inspectors found CA reports 09-049 and 09-050 inadequate to correct the deficiencies identified in violations 99901385/2009-201-01 and 99901385/2009-201-02; therefor, these violations are still open.

- C&D CA report 09-054 was initiated to resolve Nonconformance 99901385/2009-201-03 for C&D's failure to identify the root causes for quality problems and prevent their recurrence. C&D stated in their response to the NRC on November 30, 2009, (ADAMS Accession Number ML093360523) that "dedication activities were reviewed, specifically with regard to identifying equipment and calibration facilities. No other vendors who should be on the list, but are not, have been identified." However, the C&D Attica facility had not completed the extent of condition for calibration service providers using A2LA certificates; therefore, Nonconformance 99901385/2009-201-03 is still open.

- C&D CA report 09-51 was initiated to resolve Nonconformance 99901385/2009-201-04 for C&D's failure to provide an engineering justification for down-grading a battery cover's safety-related function. The CA report was closed on August 8, 2010; however, C&D was not able to provide an engineering change notice (ECN) for down-grading the battery cover's safety-related function. The inspectors found CA report 09-51 inadequate to correct this condition adverse to quality identified by the NRC in 2009. Nonconformance 99901385/2009-201-04 is still open.
- CA report 14-06 was initiated on January 8, 2014, when Nuclear Procurement Issues Committee (NUPIC) identified a failure to enter a customer complaint into the customer complaint database. Specifically, it dealt with a conformance/compliance incorrectly certified to IEEE 383-1974. The corrective action included a procedural change to the customer complaint procedure. Specifically, BI-WI-8.2.1-2, "Customer Complaints," Revision 7, now states, "the product manager has the latitude to determine those situations which may not warrant entry as a customer complaint...examples include documents that can be re-submitted to the customer within the same day due to typographical errors and other situations in which the customer is not delayed or inconvenienced by the issue." C&D responded to a NUPIC finding of not entering a condition adverse to quality into their CA process by allowing even greater latitude to enter items into their CA process. In addition, not entering situations in which the customer is not delayed or inconvenienced by the issue will bypasses C&D's corrective action process described in step 4.1 to determine corrective/preventative actions and to review corrective actions for effectiveness. In addition, if same day deficiencies are corrected and not entered into the customer complaint, corrective action, or Part 21 process, they will not be screened for Part 21 applicability. The inspectors found CA report 14-06 inadequate to correct this condition adverse to quality.

B) **Containment**: response to contain the problem and prevent additional harm to customer from incident

1) Revision to WI-8.2.1-2, "Customer Complaints to provide for Part 21 evaluations in all cases of nuclear 1E applicability and generation of this CAR.

C) **Determination of Root Cause**: Before resolution, root cause needs to be identified

1) To address the concerns identified in 99901385/2009-201-01 and 99901385/2009-201-02, a procedure review was conducted and revision 10 to A-14 was issued on 11-30-2010. In addition, a review was conducted on the incidents identified by the NRC in 99901385/2009-201-02 and it was determined at that time that the actions completed including the revision to A-14 were adequate to address the NRC's concerns.

2) With regards to 99901385/2009-201-03, the corrective action was completed as stated. The Attica facility's not completing the extent of condition for calibration suppliers using A2LA is an unrelated issue identified during the recent NUPIC audit of C&D. Since the 2014 NRC Inspection of C&D, the extent of condition of A2LA calibration suppliers has been completed with no issues identified.

3) Further review of the NRC finding by C&D shows that covers remain a dedicated component of the battery (Reference BB-QOP-7.4.3 Rev 2, in effect at time of inspection). The cover was not downgraded to a non-safety related component, however, critical characteristics of the cover have changed in accordance with BB-QOP-7.4.3 as a result of engineering evaluations. These evaluations included the effects from failure that could occur due to a component defect during a design basis event and the ability of our quality system to detect the defect prior to shipment of the product. The results were used to create and modify dedication requirements for critical characteristics of the components. In the case of the cover, the component was not downgraded, however,

Corrective / Preventive Action

dimensional variables and lot homogeneity were identified as critical characteristics as non-conformance to specifications could cause the battery jars to crack in service. These characteristics are included in dedication plans, and the cover remains a safety-related component. Material identification and other characteristics present on previous dedication plans were not found to be critical characteristics and were removed. As part of the failure mode and effects analysis (FMEA), reasons why certain properties were not critical characteristics for safety-related functions were not fully documented and were not available for review during the recent NRC inspection. These reasons are being documented and attached for review. An engineering evaluation covering changes to the dediction plan for battery covers will be available by 6-30-14.

4) The corrective action identified in response to NUPIC Finding #2 (C&D CAR 14-06) was intended to give latitude to Product Management to make determinations on a case-by-case basis for those issues identified as administrative in nature (e.g. typographical errors identified in supporting documentation which were deemed as having no impact on product safety or Part 21 applicability).

D) **Corrective Action**: Indicate the resolution plan and controls to prevent recurrence with responsibilities and target dates assigned.

1) A review of A-14 was completed with input from the NRC Inspection Team to determine verbatim compliance with 10CFR21 Reporting requirements. The procedure will be revised accordingly.

2) C&D feels that this item is unrelated to the original NRC concern namely 99901385/2009-201-03. Pending information to the contrary from the NRC, no corrective action is planned at this time other than that already in progress to address NUPIC Finding #2 (C&D CAR 14-06).

3) With regards to 99901385/2009-201-04, C&D will attempt to locate the supporting documentation to downgrade the battery cover's safety-related function to non-safety. If unable to locate, an engineering evaluation/ justification will be completed. If necessary after the conclusion of the aforementioned records search and/or evaluation, a Part 21 evaluation and applicable notifications will be conducted if a defect is identified.

4) Since the identification of the issue by the NRC Inspection Team, BI-WI-8.2.1-2, "Customer Complaints," has been revised to require evaluations launching A-14 for a 10 CFR Part 21 evaluation for all complaints related to nuclear 1E products. Additionally, regularly scheduled meetings are being conducted with Quality, Engineering, and Product Management to evaluate and document potential 10CFR, Part 21 concerns. A-14 will be revised to document this process enhancement.

All corrective actions should be complete by 8-30-2014.

Date Corrective Action Assigned: 4-30-2014 Signature of Manager: Steven T. DiMauro

E) **Verification**: Verification statement of the corrective action implementation

1)

Actual Completion Date: Verified by:

F) **Disposition**: Open

Closed by:

Date: Follow-up Date:

Y Indicate if review for 10 CFR Part 21 applicability is required (ref: C&D Standard Policy & Procedure A-14): **Y** or **N**

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Corrective / Preventive Action

Type of Action:	**Source of Action:** NRC Inspection – March, 2014
Corrective Action	**Type of Request**: NRC Inspection 99901385/2014-201

Corrective Action:RS-1037 14-18 Date Issued: April 23, 2014 Date parts B-D Due: **5-23-14**

To: Steve DiMauro, RS-1037 14-18, 99901385/2014-201-05 From: Steve DiMauro

A) **Deficiency/Non Conformity**: Describe in detail the nature of the problem, list the facts, and indicate any applicable documents. Note: include checksheet question #s - for standard references refer to the internal audit checksheet. If multifaceted with multiple assignees, identify specific assignee for each nonconformance.

Descriptive Title – Nonconforming Materials, Parts or Components

Criterion XV, "Nonconforming Materials, Parts or Components," of Appendix B to 10 CFR Part 50 states, in part, that "Measures shall be established to control materials, parts, or components which do not conform to requirements in order to prevent their inadvertent use or installation...Nonconforming items shall be reviewed and accepted, rejected, repaired or reworked in accordance with documented procedures." AQOP 8.3, "Control of Nonconforming Product," states that, "This procedure applies to all discrepant material, purchased and/or manufactured, at the C&D Technologies Attica Facility, and includes the identification, containment, documentation, disposition, and handling of raw material, completed components or finished parts and assemblies which do not conform to the specifications, drawings or fitness-for-use-criteria...Records of the nature of nonconformities and any subsequent actions taken, including concessions obtained, are maintained as describe above and as referenced in AQOP-4.2.4 [Control of Records]."

BB-QOP-7.4.3, "Commercial Grade Dedication," step 4.1.9 states, in part, that, "[i]f some of the dedication test results are outside of acceptable ranges, the Leola lab manager or the site QC manager shall arrange for segregation of item inventory, report the nonconformance, submit the results to the Director of Engineering & Quality for disposition, and shall initiate corrective action with the supplier as appropriate." Contrary to the above, as of March 3, 2014, C&D failed to review nonconforming items in accordance with documented procedures.

- C&D failed to accept a nonconforming condition for a critical characteristic, dimensions, for washer hardware in dedication plan 084/PH00907, in accordance with documented procedures. Specifically, the inspectors noted that the outer diameter for sample 5 to be minimally outside of tolerance. C&D accepted the critical characteristic as-is and failed to properly justify acceptance of the nonconforming condition in the dedication plan and enter this into their nonconformance process in accordance with AQOP-8.3, BB-QOP-7.4.3, and Criterion XV of Appendix B. C&D entered the issue into their corrective action program as CA report 14-8 dated March 6, 2014.
- C&D failed to accept a nonconforming condition for a critical characteristic, lot homogeneity, for battery containers in customer order 2393760, as required by Dedication Plan 077/PZ00651, Revision 12, dated February 22, 2011. Specifically, according to the sampling plan C&D utilized, 16 samples were needed to verify homogeneity for the lot size; however, C&D's documentation showed 2 of the 16 test samples to be from an unknown mold number. C&D accepted the critical characteristic and failed to properly justify acceptance of the nonconforming condition in the dedication plan and enter this into their nonconformance process in accordance with AQOP-8.3, BB-QOP-7.4.3, and Criterion XV of Appendix B.
- Material test laboratory report for work request no. 12-11-09-2 identified a nonconforming part, washers PH01340, lot E-17-1. An informal disposition was stamped on the report itself; however, C&D failed to enter this into their nonconformance process in accordance with AQOP-8.3 and Criterion XV of Appendix B.
- Material test laboratory report for work request no. 12-04-25-3 documents that PB00335 bolt, lot #37447, does not conform to the applicable C&D dedication plan requirements. The bolt exceeded the tensile strength requirement of 100-150 kilopounds per square inch (ksi) with a ksi of 155. An e-mail dispositioned that the bolts were okay to use via an engineering manager; however, C&D failed to enter this nonconformance into their nonconformance process in accordance with AQOP-8.3, BB-QOP-7.4.3, and Criterion XV of Appendix B.

Corrective / Preventive Action

B) **Containment**: response to contain the problem and prevent additional harm to customer from incident

1) None except generation of this CAR.

C) **Determination of Root Cause**: Before resolution, root cause needs to be identified

1) Personnel failed to follow C&D procedures with regards to the identified nonconformances. In cases where acceptance criteria tolerances were exceeded, the Manager of the Material Lab documented the condition via the use of a stamp on the dedication package and forwarded the package to the Attica facility for disposition. In these cases it was determined that the failure to meet the acceptance criteria was insignificant and would not affect the outcome of the dedications. In those cases, determinations were made without Engineering involvement or informally using emails versus following the C&D requirements delineated in AQOP 8.3 and BB-QOP-7.4.3 with regards to the use of the nonconformance process.

D) **Corrective Action**: Indicate the resolution plan and controls to prevent recurrence with responsibilities and target dates assigned.

1) All applicable personnel will be trained in the requirements of AQOP 8.3 and BB-QOP-7.4.3 to ensure a thorough understanding of the procedural requirements.

2) In addition, a review of all dedications completed since 2009 will be completed to identify those which were closed without the generation of a nonconformance.

3) If necessary after the conclusion of the aforementioned records search and/or evaluation, a Part 21 evaluation and applicable notifications will be conducted if a defect is identified.

All actions should be completed by 8-30-2014.

Date Corrective Action Assigned: 5-19-2014

Signature of Manager: Steven T. DiMauro

E) **Verification**: Verification statement of the corrective action implementation

1)

Actual Completion Date:

Verified by:

F) **Disposition**: Open

Closed by:

Date:

Follow-up Date:

Y

Indicate if review for 10 CFR Part 21 applicability is required (ref: C&D Standard Policy & Procedure A-14): **Y** or **N**

REPORT NO. QR2-07209

NUCLEAR ENVIRONMENTAL QUALIFICATION REPORT

BATTERY SECTION

PREPARED FOR: ARKANSAS POWER & LIGHT CO.
P. O. BOX 551
LITTLE ROCK, AR 72203

REFERENCE: PURCHASE ORDER NO. 01013
ARKANSAS NUCLEAR ONE - UNIT 1
125 VOLT DC STATION BATTERY

C&D BATTERIES
An ALLIED Company

Distribution:

Prepared G. WALKER G. Walker
Date Prepared 20 MAR 84
Approved F. WAGNER F. Wagner
Date Approved 3-22-84

C&D Batteries

3043 Walton Road
Plymouth Meeting, PA 19462
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TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	DESCRIPTION OF EQUIPMENT	2
3.0	PERFORMANCE REQUIREMENTS	5
4.0	ENVIRONMENTAL QUALIFICATION	6
	4.1 Radiation	6
	4.2 Electrical	7
	4.3 Seismic	8
5.0	TEST RESULTS	18
6.0	CONCLUSIONS	23
7.0	JUSTIFICATIONS	24
	7.1 Battery	24
	7.2 Battery Rack	25
	7.3 Biaxial Testing	30
8.0	LIST OF REFERENCES	31

Attachment 1 - Load Duty Cycle Battery Sizing Calculations

Attachment 2 - Pre-seismic and Post-seismic Capacity Test Results

Attachment 3 - Transmissibility Plots and Equipment List From WYLE Test No. 43450-1

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1.0 INTRODUCTION

This report presents the Nuclear Environmental Qualification of C & D BATTERIES LC-21 station battery and two step battery racks for the Arkansas One Unit Nuclear Power Station.

Qualification is provided in accordance with Arkansas Power & Light Purchase Order No. 01013 requirements as well as the guidelines set forth in IEEE Standards 323-1974, 344-1975 and 535-1979.

The basis for qualification is a review and analysis of previous test data, including results from radiation testing, thermal and natural aging, seismic tests, and battery capacity tests.

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2.0 DESCRIPTION OF EQUIPMENT

The equipment qualified by this report are the LC-21 station battery and two step battery rack for the Arkansas Nuclear One, Unit 1 Power Station.

2.1 The LC-21 battery cell consists of pasted plates with lead calcium alloy grids encased in a vented container consisting of a self-extinguishing polystyrene cover sealed to a flame retardant styrene-acrylonitrile jar. The electrolyte is sulfuric acid and water solution with a nominal fully charged specific gravity of $1.215 \pm .010$ at 77°F.

2.2 The two step battery rack consists of support frames of welded angle construction, insulated cell support and restraining rails of 12 ga. power strut, and flat cross braces. Components are coated with acid resistant, flame retardant and fungi-inert #61 grey epoxy.

2.3 The battery and racks are described in detail in C & D BATTERIES Drawing Nos. K-5629-1 and M-8536 which appear in Figures 2.1 and 2.2.

2.4 The LC-21 batteries and two step battery racks must be installed and operatied in accordance with the requirements set forth in C & D BATTERIES Section 12-800, "Stationary Battery Installation and Operating Instructions", and IEEE Std 484-1981.

2.5 Periodic maintenance and testing shall meet the requirements of IEEE Std 450-1980.

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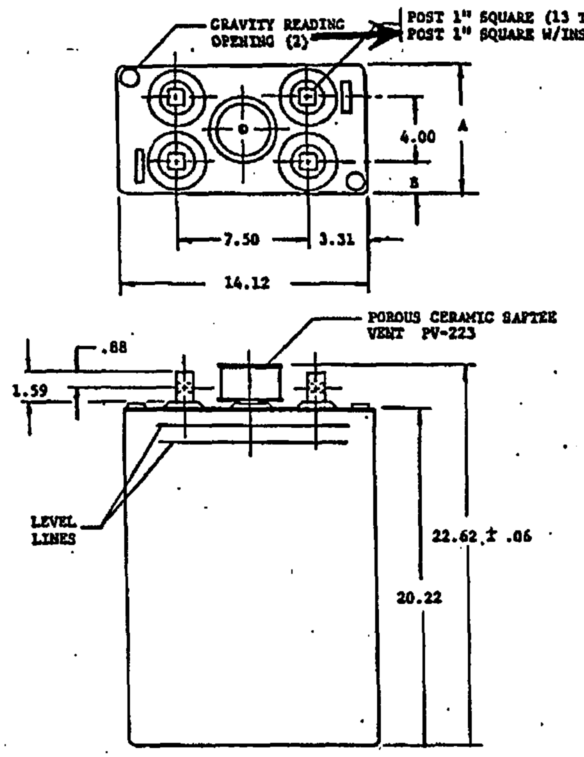

TYPE	BILL OF MATERIAL	A. HR. CAP 1 HR. R.	WGT. WET	DIMENSIONS A	DIMENSIONS B	ELECTRO #/CELL
LA-13	15179	480	196	7.62	1.81	65
LC-13	15184					
LA-15	15180	560	210			60
LC-15	15185					
LA-17	15181	636	224			58
LC-17	15186					
LA-19	12894	716	254	8.88	2.44	70
LC-19	12895					
LA-21	12896	795	270			67
LC-21	12897					
LA-23	15182	875	310	10.62	3.31	84
LC-23	15187					
LA-25	15183	954	325			82
LC-25	15188					

* PREFIX AFTER B/M NUMBER ON ORDER INDICATES THE FOLLOWING:
S = THE BATTERY IS IN A SAN CONTAINER
C = THE BATTERY IS IN A POLYCARBONATE CONTAINER

EXAMPLE:
15100-S SAN CONTAINER
15100-C POLYCARBONATE CONTAINER

FOR: ARKANSAS POWER & LIGHT CO.
ARKANSAS NUCLEAR ONE - UNIT ONE
P.O. NO. 01013
C&D INV. 02-07209

NO.	DATE	BY	REVISION
1	3-9-82	RV	Added B/M's 12894, 12895, 12896 & 12897, Rev. Title.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
TOLERANCES ON:

FRACTIONS	DECIMALS X	DECIMALS XX	DECIMALS XXX	ANGLES
—	—	±.03	—	—

MATERIAL:

PER SPEC

C&D BATTERIES
an Eltra company

OUTLINE OF LA, LC-13 THRU 25 BATTERIES

DRAWN R. YODER
APPROVED M. Warner
CHECKED [illegible]
DATE 2-24-77
DRAWING NO. K-56297
SCALE
SHEET OF

Figure 2.1 LC-21 Cell Dimensions

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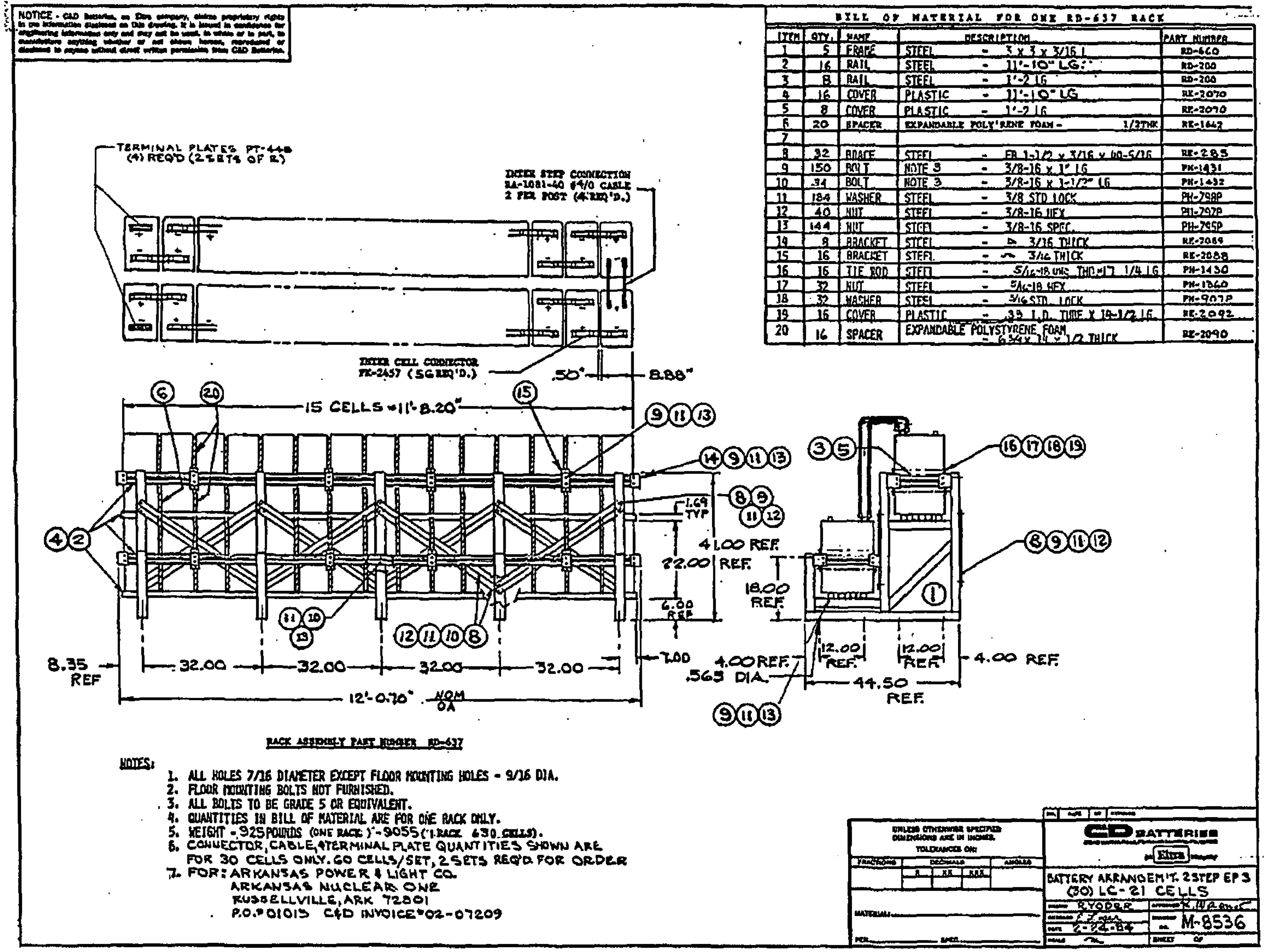

BILL OF MATERIAL FOR ONE RD-637 RACK

ITEM	QTY.	NAME	DESCRIPTION	PART NUMBER
1	5	FRAME	STEEL - 3 x 3 x 3/16 L	RD-660
2	16	RAIL	STEEL - 11'-10" LG.	RD-200
3	8	RAIL	STEEL - 1'-2 LG	RD-200
4	16	COVER	PLASTIC - 11'-10" LG	RE-2070
5	8	COVER	PLASTIC - 1'-2 LG	RE-2070
6	20	SPACER	EXPANDABLE POLY'RENE FOAM - 1/2THK	RE-1642
7				
8	32	BRACE	STEEL - FB 1-1/2 x 3/16 x 40-5/16	RE-285
9	150	BOLT	NOTE 3 - 3/8-16 x 1" LG	PH-1431
10	34	BOLT	NOTE 3 - 3/8-16 x 1-1/2" LG	PH-1432
11	184	WASHER	STEEL - 3/8 STD LOCK	PH-798P
12	40	NUT	STEEL - 3/8-16 HEX	PH-797P
13	144	NUT	STEEL - 3/8-16 SPEC.	PH-795P
14	8	BRACKET	STEEL - 3/16 THICK	RE-2089
15	16	BRACKET	STEEL - 3/16 THICK	RE-2088
16	16	TIE ROD	STEEL - 5/16-18 UNC THD x 17 1/4 LG	PH-1430
17	32	NUT	STEEL - 5/16-18 HEX	PH-1360
18	32	WASHER	STEEL - 5/16 STD. LOCK	PH-907P
19	16	COVER	PLASTIC - .35 I.D. TUBE X 18-1/2 LG.	RE-2092
20	16	SPACER	EXPANDABLE POLYSTYRENE FOAM - 6 3/4 X 14 X 1/2 THICK	RE-2090

NOTES:

1. ALL HOLES 7/16 DIAMETER EXCEPT FLOOR MOUNTING HOLES - 9/16 DIA.
2. FLOOR MOUNTING BOLTS NOT FURNISHED.
3. ALL BOLTS TO BE GRADE 5 OR EQUIVALENT.
4. QUANTITIES IN BILL OF MATERIAL ARE FOR ONE RACK ONLY.
5. WEIGHT = 925 POUNDS (ONE RACK) - 9055 (1 RACK & 30 CELLS).
6. CONNECTOR, CABLE & TERMINAL PLATE QUANTITIES SHOWN ARE FOR 30 CELLS ONLY. 60 CELLS/SET, 2 SETS REQ'D FOR ORDER
7. FOR: ARKANSAS POWER & LIGHT CO.
   ARKANSAS NUCLEAR ONE
   RUSSELLVILLE, ARK 72801
   P.O. # 01015 C&D INVOICE # 02-07209

Figure 2.2 Battery Rack Dimensions, Components and Cell Arrangement

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3.0 PERFORMANCE REQUIREMENTS

3.1 The battery, when installed and maintained in accordance with the guidelines set forth in C & D BATTERIES Installation and Operating Instructions, and IEEE Standards 450-1980 and 484-1981, shall remain functional for a period of 20 years from the date of shipment.

The battery shall, at any time during its qualified life, be capable of supplying the specified design loads without the voltage at the battery terminals falling below 1.81 average volts per cell while experiencing any single or combination of the following environmental conditions.

a. Ambient temperature range of +77°F to +95°F and an annual average temperature of +80°F or less.

b. Relative humidity from 0 to 100%.

c. Total integrated radiation dose of 1 x 10^4 rads.

d. Seismic events of the specified intensities.

3.2 The battery racks shall be capable of supporting the battery cells and their interconnecting devices without damage, and shall maintain structural integrity and support function throughout the life of the battery, and during or following specifed Operating Basis or Design Basis Earthquakes.

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4.0 ENVIRONMENTAL QUALIFICATION

4.1 Radiation

If the total integrated dosage over the life of the equipment does not exceed 10^4 rads, IEEE Std 535-1979 stipulates that no radiation exposure is required for qualification. This is because no battery or rack component is adversely affected by radiation at equal or lower values. Supporting evidence, from NATIONAL TECHNICAL INFORMATION SERVICES' Radiation Effects on Materials, is given in TABLE 1 and lists non-metallic components employed for battery cells and battery racks along with the radiation dosage they are capable of withstanding (the radiation damage threshold) without compromising the design properties of the materials.

Since all damage threshold levels are substantially greater than 10^4 rads, no additional device or component testing is required.

COMPONENT	MATERIAL	RADIATION DAMAGE THRESHOLD (rads)	DOSE CAUSING SIGNIFICANT DAMAGE (rads)
Cell Jar	Styrene-acrylonitrile	1×10^8	1×10^9
Cell Cover	Polystyrene	1×10^8	4×10^9
Flame Arrestor	Polystyrene	1×10^8	4×10^9
Element Spacer	Styrene-butadiene	1×10^6	1×10^7
Plate Separator	Natural Rubber, or	1×10^6	1×10^7
	Polyester Fiber Reinforced Sheets Impregnated with Phenol Formaldehyde	1×10^6	1×10^7
Rack Rail Cover	Polyethylene	3×10^7	1×10^9
Tie Rod Cover	Polyethylene	3×10^7	1×10^9
Cell Spacer	Polystyrene	1×10^8	4×10^9

TABLE 1

Radiation Effects on Battery and Battery Rack Materials

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4.2 Electrical

Since battery capacity is increased at temperatures above 77°F, and decreased at temperatures below this value, the worse case condition for the battery to deliver the specified design currents is at the minimum specified battery room ambient. This is not specified and is presumed to be 77°F.

The battery must also be capable of supplying the design loads throughout its qualified life, and therefore must have adequate design margin so that if capacity has degraded to 80% of the original published ratings (end of battery service life), the design loads will still be carried for the prescribed time periods and battery voltage will still remain above specified minimum values. Battery sizing calculations for both the "D06" and D07" load duty cycles are included in Attachment 1, and show that the LC-21 battery has adequate margins to meet these requirements.

For reference, the specified load duty cycles are given below.

BATTERY "D06" Ampere Load	BATTERY "D07" Ampere Load	Time Period Minutes
829	797	0 - 1
659	627	1 - 3
609	577	3 - 30
115	325	30 - 120
37	47	120 - 239
187	197	239 - 240

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4.3 Seismic

Seismic qualification is based on previous qualification testing of various LC type battery cells. For the purpose of this report we will compare existing seismic test data for battery cell types listed in TABLE 2.

The construction and operating characteristics of the tested cells are identical to the Arkansas Nuclear One batteries. Component location and materials employ the same overall geometry to carry loads as the Arkansas Nuclear One LC-21 battery. For a comparison of the battery cell dimensions and construction features between the Arkansas Nuclear One battery and the seismically tested models, refer to Figures 4.1, 4.2, 4.3 and 4.4.

CELL TYPE		QTY	CAPACITY	RATE	JAR MATERIAL *
4LCY-11	(unaged)	1	330 AH	1 Hr	SAN
LC-15	(unaged)	2	1050 AH	8 Hr	PC
LC-25	(unaged)	2	1800 AH	8 Hr	PC
LCU-27	(6 yr naturally aged)	2	1950 AH	8 Hr	SAN
LC-29	(unaged)	2	1008 AH	1 Hr	PC
LCY-39	(unaged)	2	1330 AH	1 Hr	PC
CT-1440	(25 yr naturally aged)	2	1440 AH	8 Hr	PC

* SAN = Stryene-acrylonitrile
PC = Polycarbonate

TABLE 2 Battery Cell Types Seismically Tested

Seismic qualification of the battery rack is based on previous tests and analysis conducted on a rack identical in design and material as the Arkansas Nuclear One battery racks. Figure 4.5 shows the two step test rack and the mounted LC type cells as it existed for simulated seismic testing.

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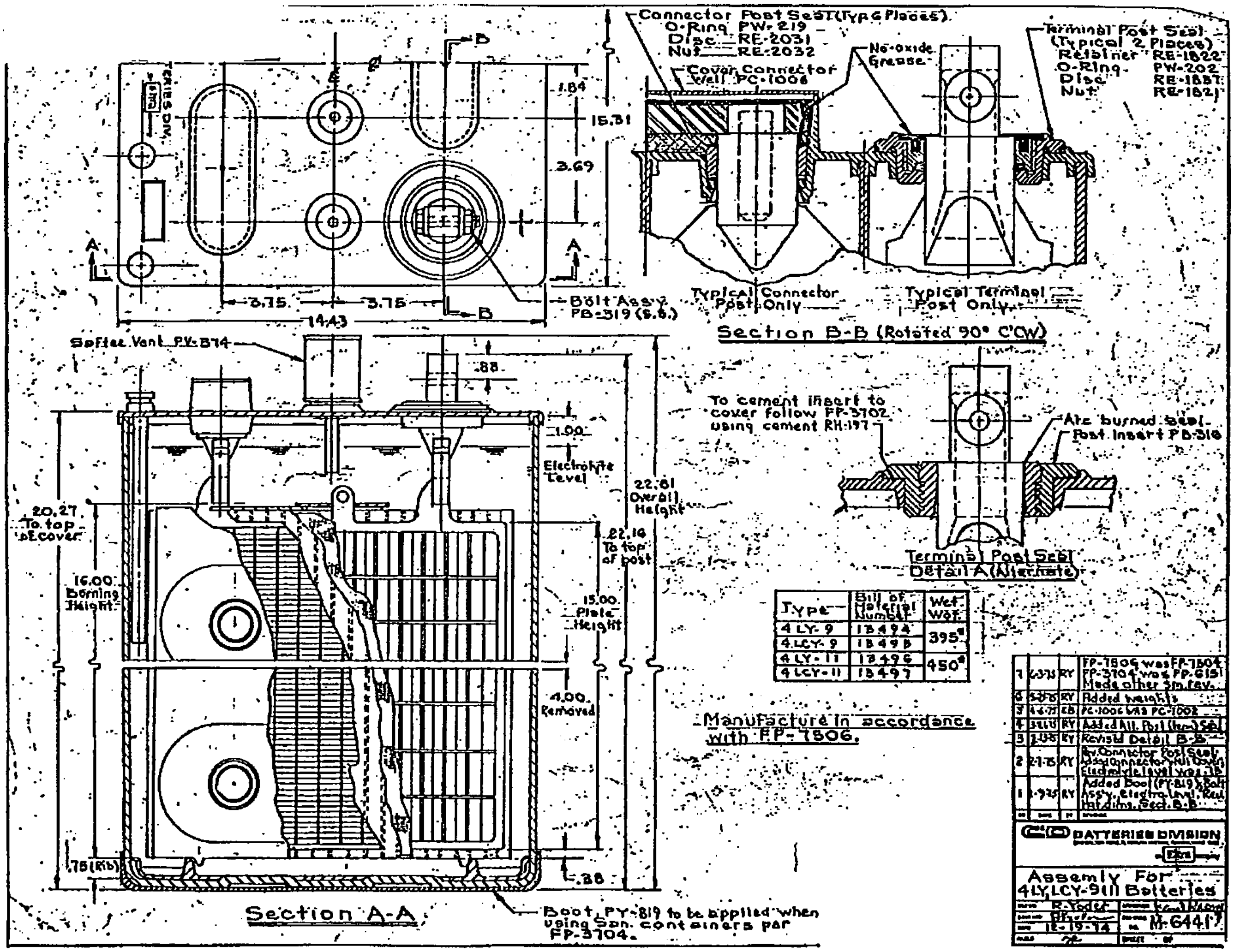

Type	Bill of Material Number	Wet Wt.
4 LY-9	13494	395#
4 LCY-9	13498	
4 LY-11	13496	450#
4 LCY-11	13497	

Figure 4.1 Construction Details for Type 4LCY-11

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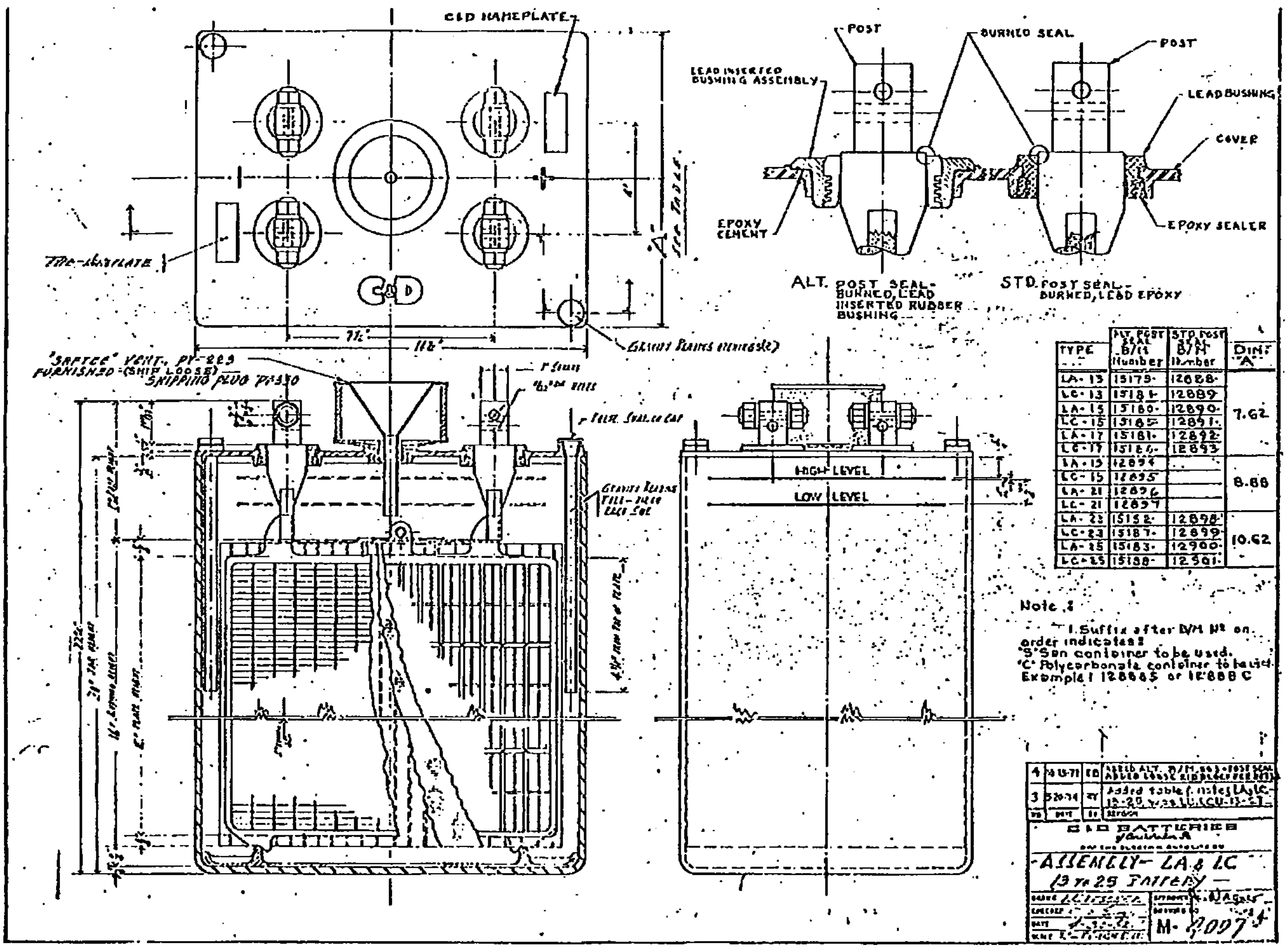

Figure 4.2 Construction Details for Types LC-15, LC-21, LC-25 and LCU-27

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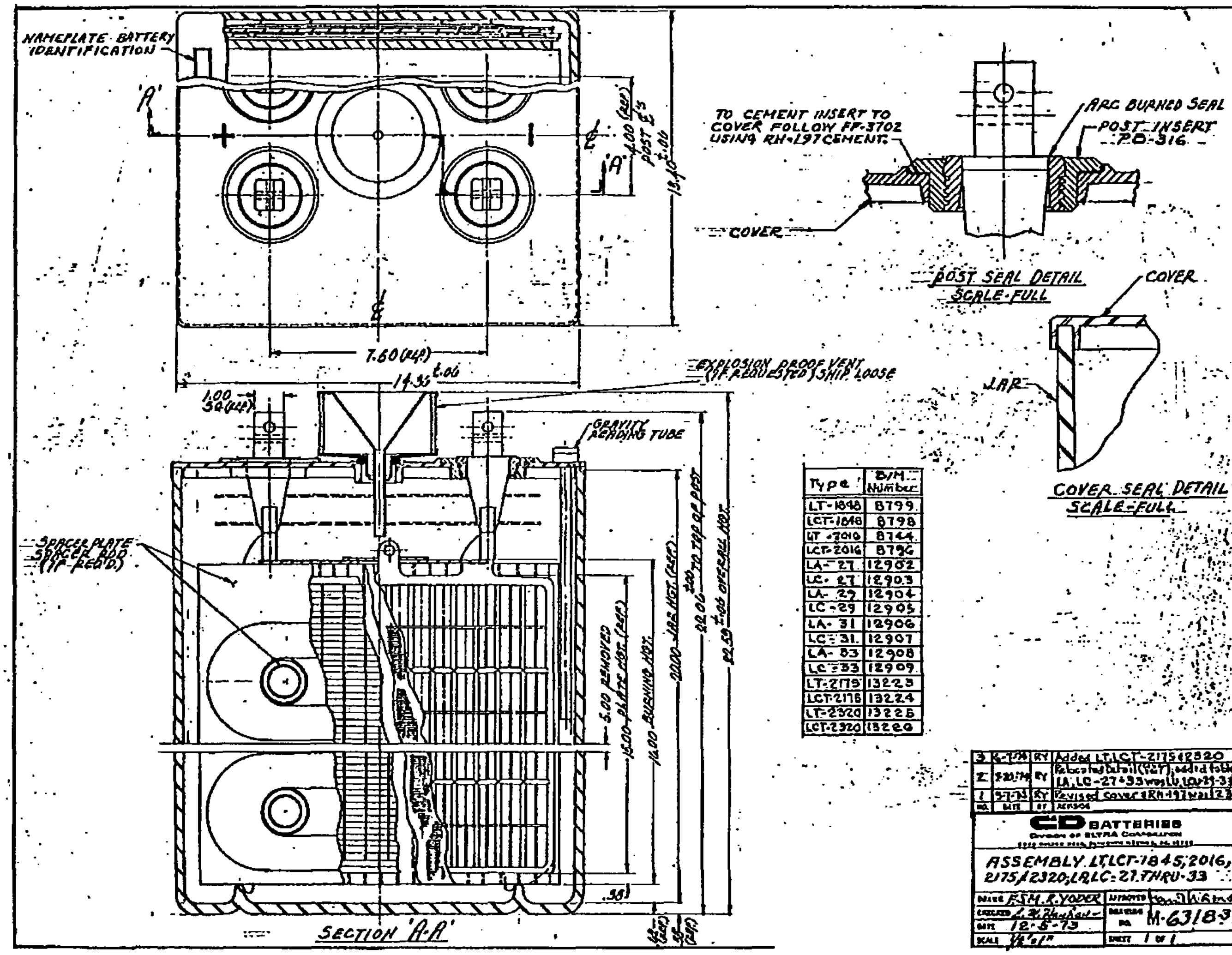

Type	B/M Number
LT-1848	8799
LCT-1848	8798
LT-2016	8744
LCT-2016	8796
LA-27	12902
LC-27	12903
LA-29	12904
LC-29	12905
LA-31	12906
LC-31	12907
LA-33	12908
LC-33	12909
LT-2175	13223
LCT-2176	13224
LT-2320	13225
LCT-2320	13220

Figure 4.3 Construction Details for Types LC-29 and CT-1440

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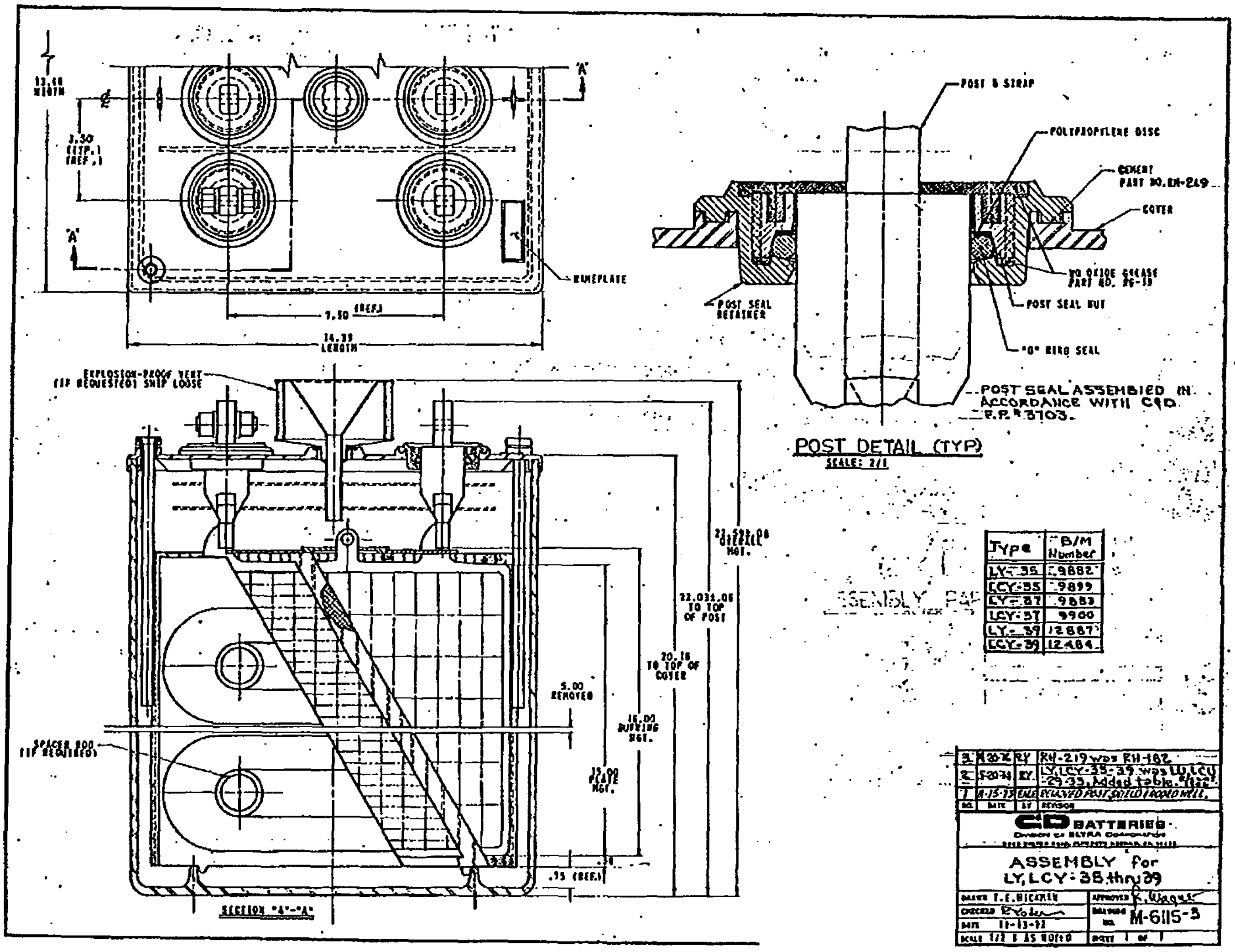

Figure 4.4 Construction Details for Type LCY-39

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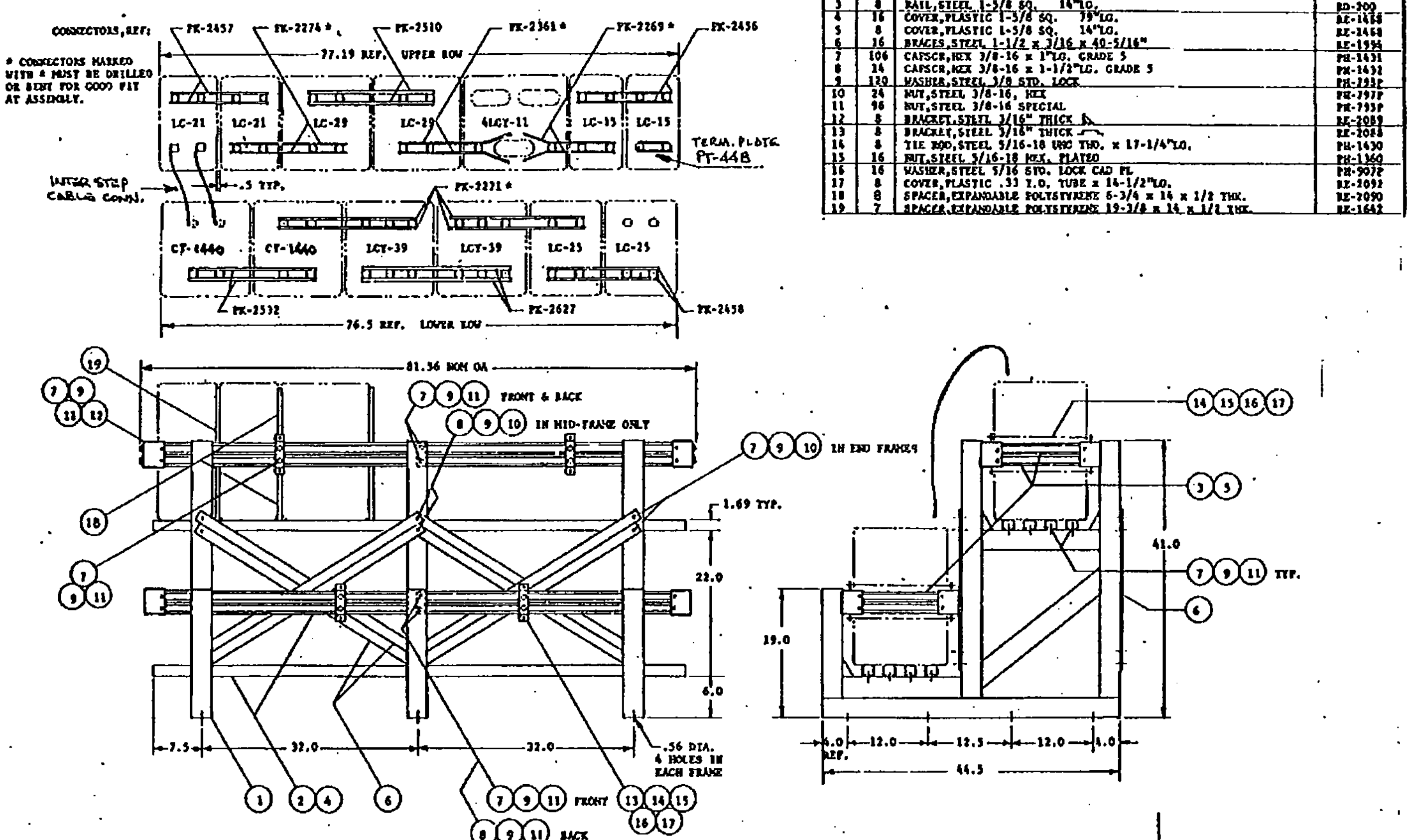
ITEM	QTY.	BILL OF MATERIAL, TEST RACK - RD-661 DESCRIPTION	PART NUMBER
1	3	FRAME, STEEL 3 x 3 x 3/16" L	RD-660
2	16	RAIL, STEEL 1-5/8 SQ. 79"LG.	RD-200
3	8	RAIL, STEEL 1-5/8 SQ. 14"LG.	RD-300
4	16	COVER, PLASTIC 1-5/8 SQ. 79"LG.	RE-1468
5	8	COVER, PLASTIC 1-5/8 SQ. 14"LG.	RE-1468
6	16	BRACES, STEEL 1-1/2 x 3/16 x 40-5/16"	RE-1994
7	106	CAPSCR, HEX 3/8-16 x 1"LG. GRADE 5	PH-1431
8	14	CAPSCR, HEX 3/8-16 x 1-1/2"LG. GRADE 5	PH-1432
9	120	WASHER, STEEL 3/8 STD. LOCK	PH-793P
10	24	NUT, STEEL 3/8-16, HEX	PH-797P
11	96	NUT, STEEL 3/8-16 SPECIAL	PH-793P
12	8	BRACKET, STEEL 3/16" THICK	RE-2089
13	8	BRACKET, STEEL 3/16" THICK	RE-2088
14	8	TIE ROD, STEEL 5/16-18 UNC THD. x 17-1/4"LG.	PH-1430
15	16	NUT, STEEL 5/16-18 HEX. PLATED	PH-1360
16	16	WASHER, STEEL 5/16 STD. LOCK CAD PL	PH-9072
17	8	COVER, PLASTIC .33 I.D. TUBE x 14-1/2"LG.	RE-2092
18	8	SPACER, EXPANDABLE POLYSTYRENE 6-3/4 x 14 x 1/2 THK.	RE-2090
19	7	SPACER, EXPANDABLE POLYSTYRENE 19-3/8 x 14 x 1/2 THK.	RE-1642



NOTES:-
1. PAINT - ACID RESISTANT GRAY.
2. FLOOR MOUNTING HOLES ARE 9/16 DIA.
3. FLOOR MOUNTING BOLTS ARE NOT FURNISHED; USE GRADE 5 OR EQUIVALENT.
4. WEIGHT, RACK ONLY, 530 LBS.
5. TOTAL WEIGHT: 4840 LBS

1-1-76	EL	CORRECTED QTY'S
C&D BATTERIES DIVISION		
TEST RACK 2-STEP SEISMIC, TYPE L UNITS		
EARL LOSER		
E.D. BAILEY		
3-9-76		M-6703-1

Figure 4.5 Two Step Seismic Test Rack and Mounted Test Cells

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The Qualification Program as it applies to this report is discussed in the following sections.

4.3.1 Capacity Tests

The battery cells were subjected to capacity tests prior to, and following the seismic tests. The capacity tests were performed in accordance with the applicable procedures described in IEEE Standard 450.

All unaged cells were at 100% rated capacity prior to the start of the test program, and remained so throughout.

All aged cells retained capacities greater than 80% throughout the test program.

Attachment 2 includes the pre-seismic and post seismic capacity test results for each of the cell types tested.

4.3.2 Aging (ref. TABLE 2)

The CT-1440 was a 25 year old (at the time of the seismic test) cell that was manufactured in 1951 as part of a 60 cell lead calcuim battery. At that time the cells were encased in hard rubber jars and had a nomenclature RCT-1680 - rated 1680 ampere hours at the 8 hour rate of discharge. The battery was purchased by the Bell Telephone System and installed at their Pennypacker Exchange Office, Philadelphia, PA as an emergency power source, where the battery operated for 17 trouble-free years.

In 1968, when the Exchange was being enlarged, the battery was re-aquired by C & D BATTERIES. It was stored for one year until the Plymouth Meeting Headquarters Building was completed and, in the Spring of 1970, it was installed there for use as an emergency lighting system.

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For the purpose of this test and for future visual observation, the elements of two cells were removed from their original containers and placed in plastic jars with plastic covers and a bottom plate support system similar to that employed in currently produced cells. In order to facilitate the jar transfer, two positive plates and two negative plates were removed, re-rating the cells from 1680 to 1440 ampere hours.

The 6 year old LCU-27 cells were returned to C & D by Pacific Gas & Electric from their Diablo Canyon Nuclear Power Plant for qualification to a revised seismic spectrum. Data on these cells will not be used to qualify the Arkansas Nuclear One batteries.

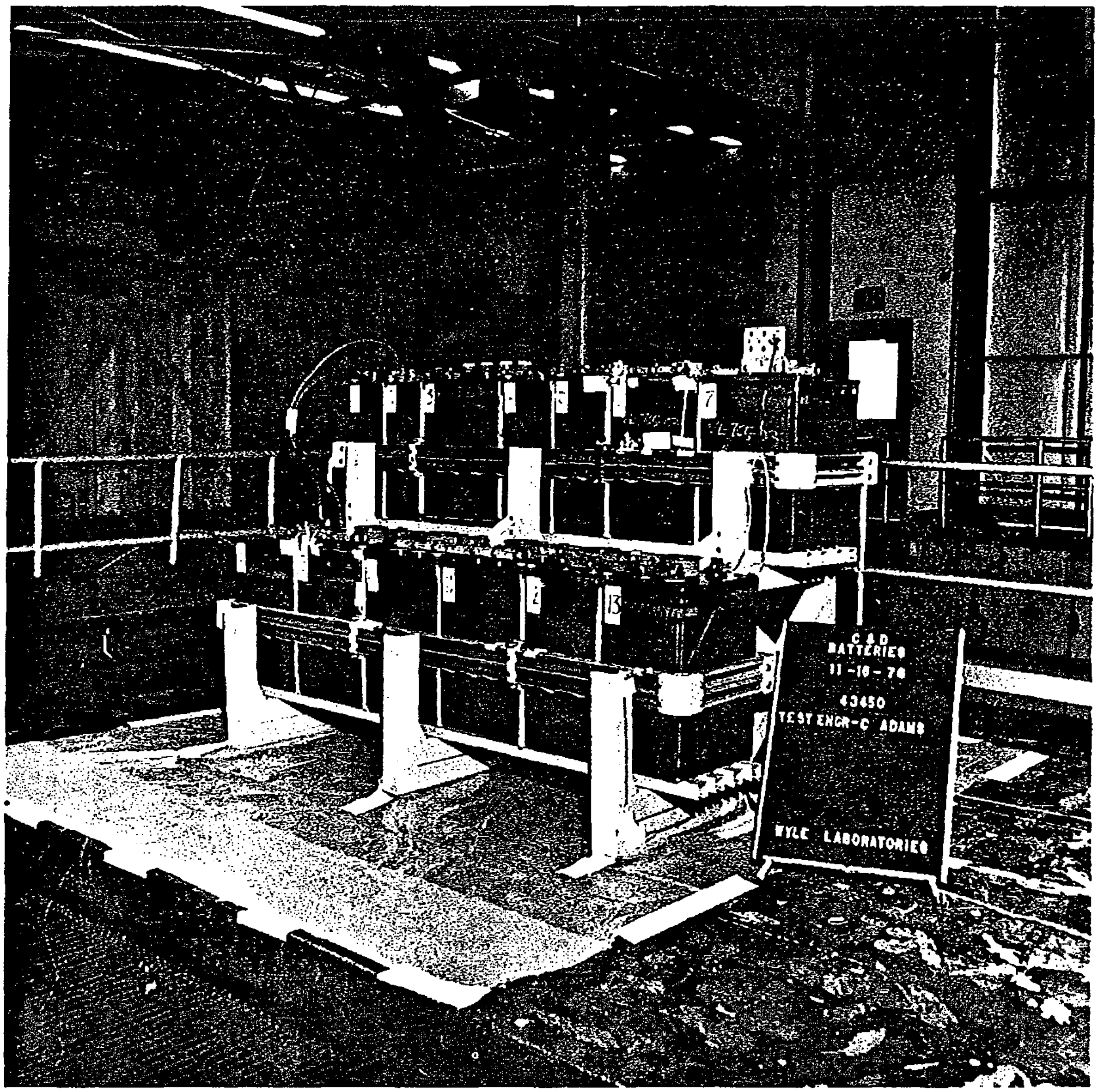
4.3.3 Seismic Test Procedure

Sixteen cells, from the largest container to the smallest, of various LC type batteries were mounted in the normal manner and connected in series on a two step battery rack. This battery and rack assembly was then subjected to simulated seismic testing per WYLE LABORATORIES Test Report No. 43450-1.

The test rack was bolted directly to the WYLE test table at each bolting location in the rack foundation using 1/2 inch SAE Grade 5 bolts. This procedure was used for each test orientation. Photograph 1 shows the test rack and cells as mounted on the test table.

One vertical and one horizontal control accelerometer were mounted on the test table. TRS plots were taken from these control accelerometers at the time of the test for each test axis.

The battery rack and battery cells were instrumented with uniaxial horizontal and vertical response accelerometers in various locations. The horizontal accelerometers were oriented in the front-to-back direction during FB/V testing and were oriented in the side-to-side direction during SS/V testing.



Photograph 1 Test Rack and LC Test Cells

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The battery cells were connected in series to a resistive load of approximately 20 amperes during all phases of the seismic tests. The battery output voltage and current were recorded on an oscillograph recorder during the seismic test program. These monitoring channels were used to determine electrical continuity, current and voltage levels, and to detect any spurious operation before, during, and after the test program.

Testing consisted of a low-level resonance search, followed by random multifrequency qualification tests in each axis. Qualification tests in each axis included five (5) Operating Basis Earthquake (OBE) tests prior to one (1) Design Basis Earthquake (DBE) test.

A low-level (approximately 0.1 to 0.2 g horizontal and vertical) biaxial sine sweep was performed to determine natural frequencies of the equipment which might result in large responses during multifrequency testing. For each test orientation, the frequency range of the sine sweep was from 1 Hz to 40 Hz at a sweep rate of 1/2 octave per minute.

The test specimens were subjected to 30 second duration simultaneous horizontal and vertical inputs of phase incoherent random waveform motion consisting of frequency bandwidths spaced 1/3 octave apart over the frequency range of 1 Hz to 40 Hz. For the second sequence of tests, the test specimen was rotated 90° in the horizontal plane. For each test orientation, a full compliment of testing was performed, i.e., resonance search test, 5 OBE tests, and 1 DBE test.

Attachment 3 contains the WYLE Transmissibility Plots, Equipment List, and Seismic Test Procedure for this Test Program.

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5.0 TEST RESULTS

The battery cells and the battery rack successfully completed the simulated seismic test program. Test results and inspection showed that they possessed sufficient integrity to withstand, without compromise of structure or function, the seismic test environment. The oscillograph records did not indicate any spurious or improper operation or deviation in the output voltage/current levels of the battery, either during or after the seismic excitation.

Post-seismic capacity tests conducted on the battery cells yielded capacities essentially identical to those recorded prior to the seismic test program. Unaged cells retained capacities of 100% or greater. The 25 year old naturally aged cells delivered capacities over 80%.

Although this qualification program was not specifically performed as a proof test for the Arkansas Nuclear One batteries and battery racks, its applicability is demonstrated due to the identical design of all LC type battery cells and two step battery racks. The WYLE Test Response Spectrum (TRS) envelops the Arkansas Nuclear One Required Response Spectrum (RRS) in excess of 10% at all test frequencies. Figures 5.1 through 5.4 shows the OBE and DBE horizontal and vertical WYLE TRS versus the Arkansas Nuclear One RRS.

C&D BATTERIES

Arkansas Power & Light
Arkansas Nuclear One
Unit 1

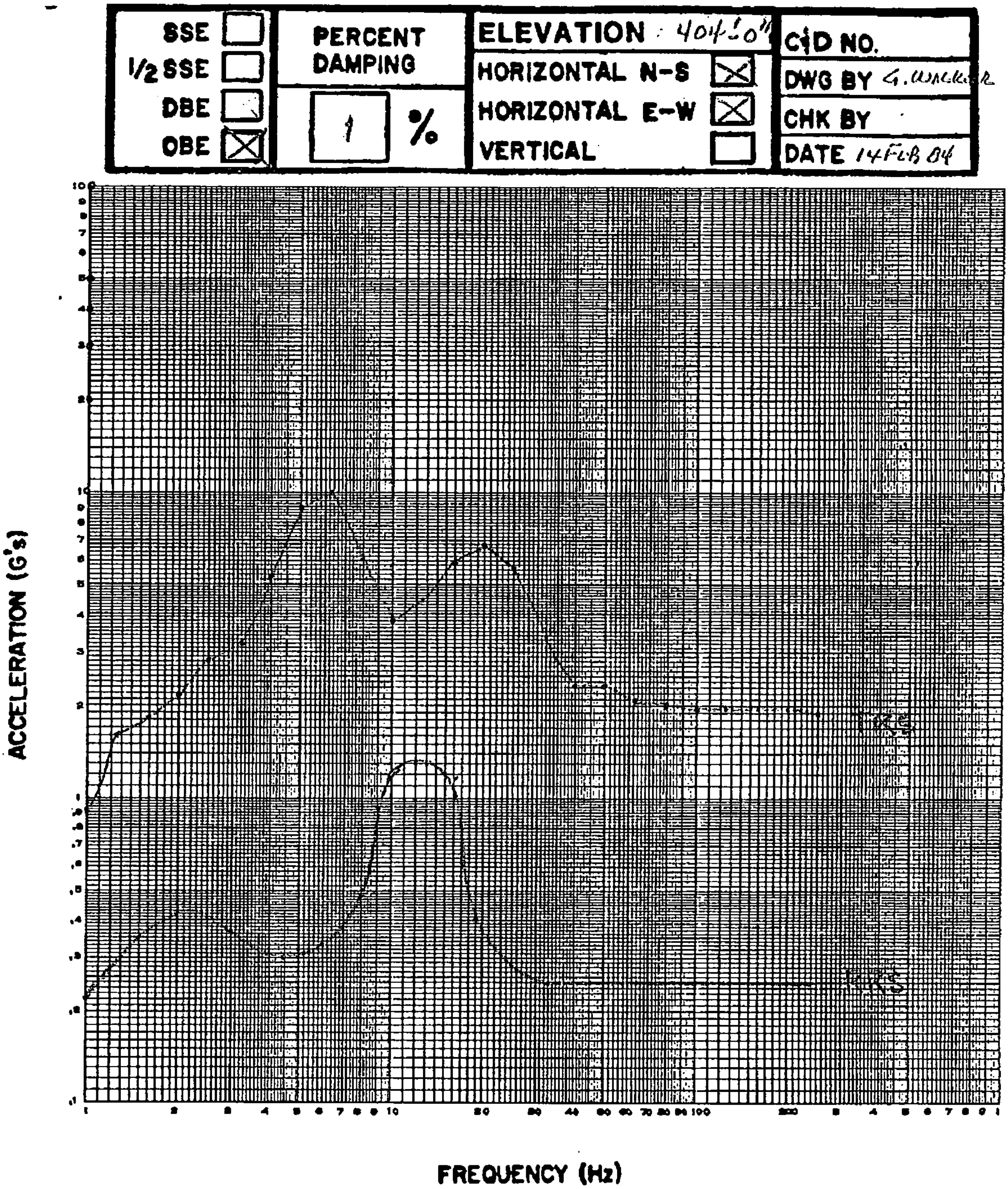

Figure 5.1 Wyle Test No. 43450-1 Horizontal TRS vs. RRS For The LC Type Cells and Rack

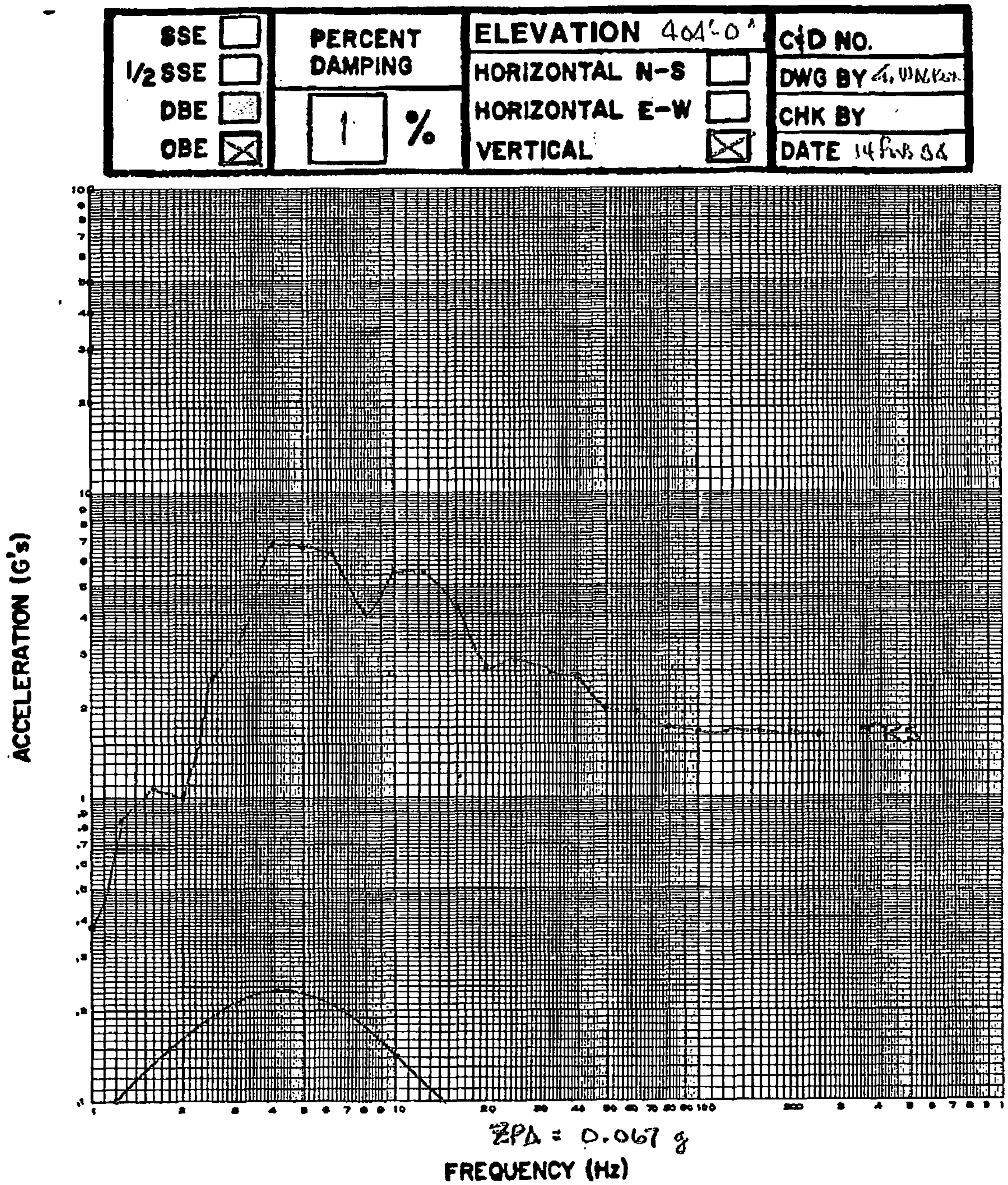

Figure 5.2 Wyle Test No 43450-1 Vertical TRS vs. RRS For The LC Type Cells and Rack

SSE ☐	PERCENT DAMPING	ELEVATION 404'-0"	C&D NO.
1/2 SSE ☐		HORIZONTAL N-S ☒	DWG BY Glenn
DBE ☒	1 %	HORIZONTAL E-W ☒	CHK BY
OBE ☐		VERTICAL ☐	DATE 14Feb84

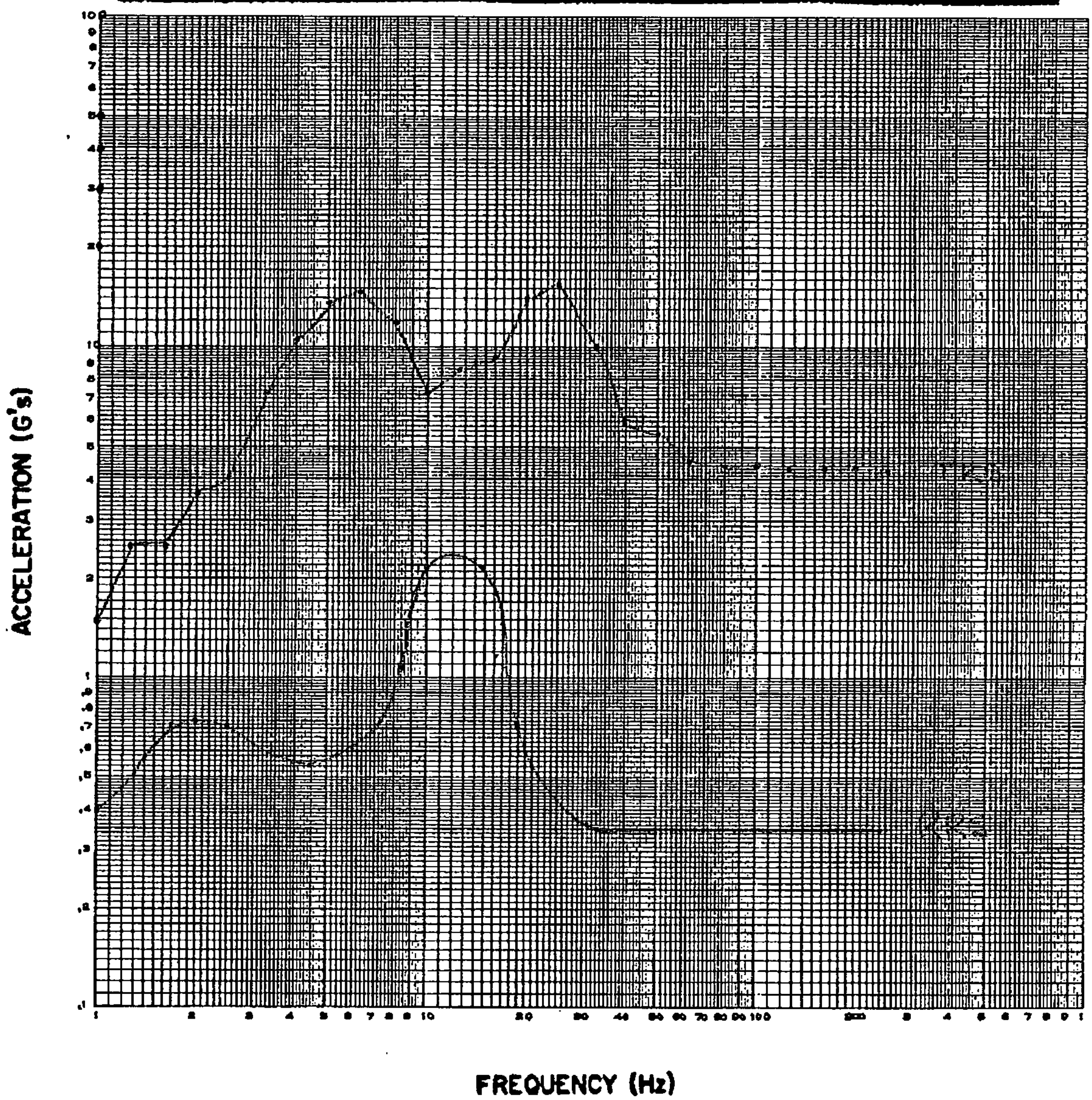

Figure 5.3 Wyle Test No. 43450-1 Horizontal TRS vs. RRS For The LC Type Cells and Rack

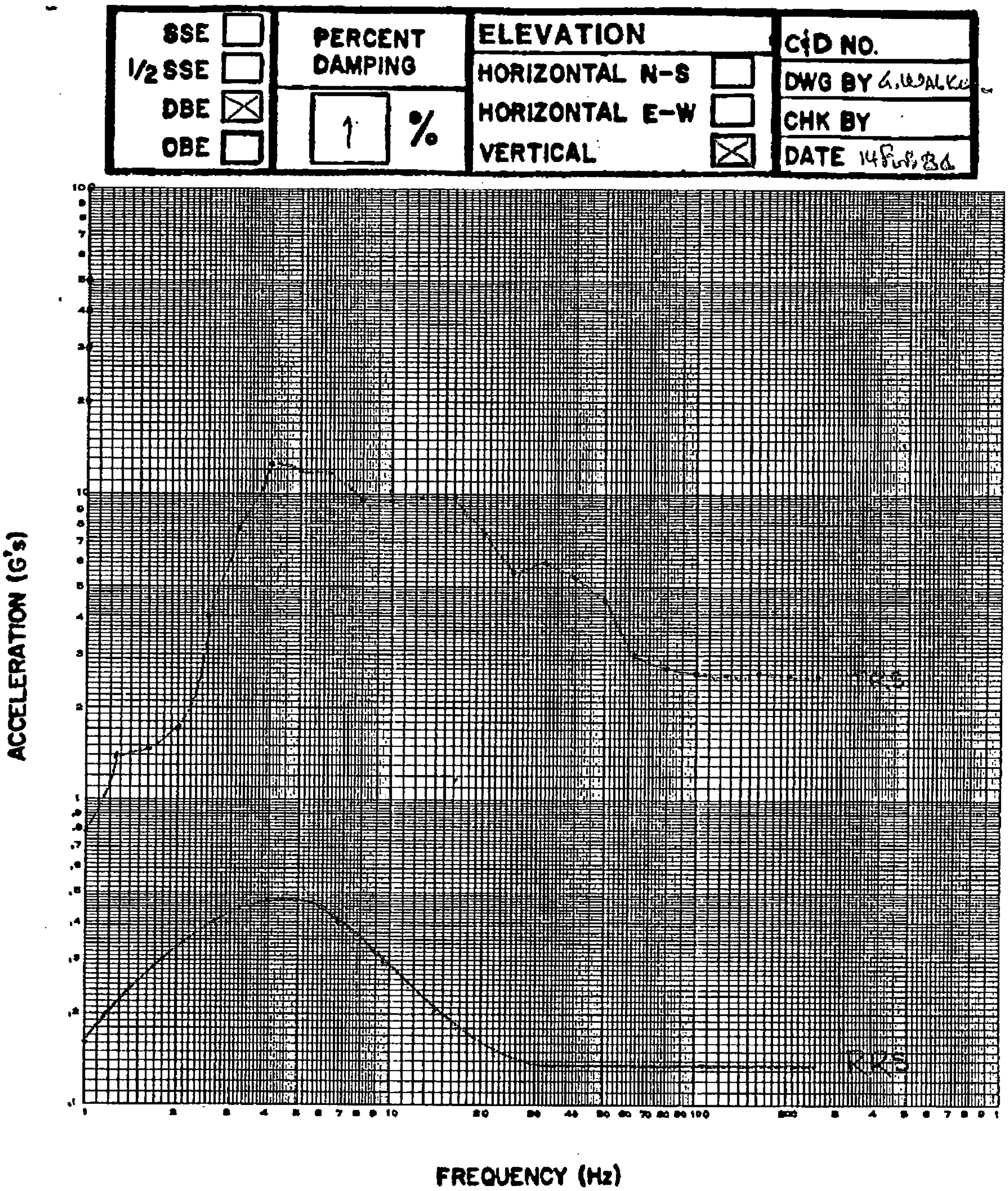

Figure 5.4 Wyle Test No. 43450-1 Vertical TRS vs. RRS For The LC Type Cells and Rack

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6.0 CONCLUSIONS

The 125 Volt LC-21 station battery is environmentally qualified for a period of 20 years, when maintained in accordance with recommended and approved procedures, for service in the Arkansas Nuclear One, Unit One Nuclear Power Plant.

Previous seismic qualification testing of LC type battery cells and two step battery rack demonstrated that they possess sufficient integrity to withstand without compromise of structure or function, the seismic environment of the Arkansas Nuclear One Power Station.

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7.0 JUSTIFICATIONS

7.1 Battery

The Arkansas Nuclear One LC-21 station battery is qualified by similarity based on test data from WYLE LABORATORIES Test Report No. 43450-1. This test program included unaged and aged battery cells. TABLE 3 below shows the physical similarity of the plates of all the test cells.

PLATE NOMENCLATURE	HEIGHT	WIDTH	PLATE THICKNESS
CT	13.25"	11.5"	0.266" (Pos.), 0.180" (Neg.)
LC	15.00"	12.0"	0.312" (Pos.), 0.210" (Neg.)
LCY	15.00"	12.0"	0.250" (Pos.), 0.180" (Neg.)

TABLE 3 Plate Dimensions For Cell Type CT, LC, LCY

All test cells were constructed with lead calcium grids and employed identical construction materials and features.

Comparing the Arkansas Nuclear One LC-21 cells with the naturally aged CT-1440 test cells is justified because degradation (embrittlement) of the positive plates is the predominant failure mode in lead acid storage batteries, and since the float charging current is proportional to rated positive plate capacity - and life is proportional to plate thickness - the corrosion rate of the plate grid structure will be identical; and the CT-1440 and LC-21 batteries will degrade at the same rate since both positive plates are the same material and design.

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The thickness of the CT positive plate is less than that of the LC positive plate, therefore, the ability of a naturally aged CT-1440 battery to successfully withstand a seismic test, demonstrates that a naturally aged LC-21 battery would be able to withstand the same seismic loads since the CT plates are in a mechanically weaker condition.

Additionally, Nuclear Environmental Qualification Report No. QR-1-72042, dated 7 Feb 83, and already in your possession, shows that LC cells thermally aged per the requirements of IEEE-535-1979 to an equivalent life of 20 years of normal service, are capable of exceeding the environmental requirements of the Arkansas Nuclear One Power Plant.

7.2 Battery Rack

Qualification of the Arkansas Nuclear One battery racks (Figure 2.2) is based on similarity to a representative rack previously tested. TABLE 4 provides a comparison of the tested rack and the Arkansas Nuclear One rack for the LC-21 batteries.

Justification for testing a two-bay rack to qualify a four-bay rack is accomplished by showing the structural behavior of a two-bay model is similar to that of a four-bay model. The results from two finite element analyses from Reference 4 are compared to demonstrate seismic equivalence between typical two-bay and five-bay racks. The finite element analyses were performed using the computer program STARDYNE. STARDYNE is a well known, well documented proprietary computer program widely accepted for this type of analysis by both industry and the Nuclear Regulatory Commission.

The results of the analyses compared are the equipment natural frequencies and beam stresses from statically applied 1 g seismic loads in each of the three directions. These results are chosen for comparison because they present the dynamic and structural response of the mathimatical models. The complete results, with a description of the analyses, are contained in Reference 4.

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	TESTED RACK	ARKANSAS NUCLEAR ONE RACK
CELL TYPE	LC	LC-21
LINEAR BATTERY WEIGHT/INCH		
(total)	27.92 lb/in	27.99 lb/in
(between frames)	28.18 lb/in	28.12 lb/in
RESONANT FREQUENCY		
(front-to-back)	13 Hz	13 Hz
(side-to-side)	12 Hz	12 Hz
(vertical)	28 Hz	28 Hz
STEEL STRUCTURAL MEMBERS		
(frames)	3 x 3 x .19 in	3 x 3 x .19 in
(rails)	1.6 x 1.6 x 12 ga	1.6 x 1.6 x 12 ga
(cross braces)	1.5 x .19 in	1.5 x .19 in
(end rail brackets)	.19 in Thick	.25 in Thick
(tie rods)	.31 - 18 UNC Thd	.31 - 18 UNC Thd
(tie rod brackets)	.19 in Thick	.19 in Thick
(hardware)	SAE Grade 5	SAE Grade 5
FRAME SPACING	32 in	32 in

TABLE 4 Comparison of Tested Rack and Arkansas Nuclear One Rack for LC-21 Battery

Figures 7.1 and 7.2 present the natural frequencies of the two-bay and five-bay mathematical models. The natural frequencies closely agree, and thus, the four-bay LC-21 battery rack for the Arkansas Nuclear One Plant is judged to have natural frequencies equal to the tested rack.

TABLE 5 presents a comparison of the beam member stresses. The three directions of seismic load were combined by the SRSS method. No appreciable difference in stress occurs between the two-bay model and the five-bay model. Each bay has identical bracing in each direction. Additional bays provide their own bracing. Test Response Spectra are shown to completely envelope the Required Response Spectra, therefore the two-bay rack is structurally adequate and represents the behavior of a multi-bay rack.

LANCZOS ANALYSIS OF A 2 BAY LC-25 BATTERY RACK

MODAL EXTRACTION DATA

MODE NO	EIGENVALUE (OMEGA**2)	NATURAL FREQUENCY	PERIOD	GENERALIZED WEIGHT	MAX TRANSLATION NODE-DOF	MAX TRANSLATION VALUE	--- MODAL WEIGHTS --- (GEN. WGT. * PARTICIPATION FACTORS**2) X1	X2	X3	
1	7222.13	13.525	.0739	1705.08	103-1	1.0000	3869.22470	8.12430	.04364	12.0
2	9969.10	15.891	.0629	2152.08	126-2	1.0000	225.22687	2758.51168	4.93368	12.0
3	10593.2	16.381	.0610	2393.69	122-2	1.0000	483.09847	493.78670	.20446	12.0
4	12548.0	17.828	.0561	1642.51	128-2	1.0000	261.55688	3.32210	.07585	12.0
5	25042.2	25.186	.0397	2631.62	126-1	1.0000	27.61915	12.63633	.47375	12.0
6	28373.6	26.809	.0373	854.289	46-2	1.0000	1.10358	1007.21448	5.91763	12.0
7	31545.8	28.268	.0354	971.804	91-3	1.0000	.85704	.51947	.00113	7.7
8	31656.4	28.317	.0353	974.353	75-3	1.0000	.00169	.14645	.00002	8.8
9	32917.9	28.876	.0346	1178.95	98-3	1.0000	.00259	.01070	.00036	5.7
10	32931.6	28.882	.0346	1185.31	84-3	1.0000	.01091	.00471	.00079	5.9

THE FOLLOWING ARE APPROX. EIGENVALUES FOR WHICH MODES WERE NOT REQUESTED.

MODE NO	EIGENVALUE (OMEGA**2)	NATURAL FREQUENCY	
11	34214.4	29.439	8.4
12	43383.7	33.150	7.2
13	45883.6	34.092	6.5
14	51907.2	36.260	5.6
15	55488.4	37.490	4.5
16	67045.3	41.210	2.7

LANCZOS REDUCED MATRIX SIZE (DOF) = 33
APPROX. MAXIMUM EIGENVALUE(OMEGA**2)= .135986E+08

NOTE THE LAST COLUMN IN THE TABLE ABOVE IS RELATED TO EIGENVALUE ACCURACY BOUNDS.

Figure 7.1 Natural Frequencies of Two-Bay LC-25 Battery Rack

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LANCZOS ANALYSIS OF A 5 BAY LC-25 BATTERY RACK

MODAL EXTRACTION DATA

MODE NO	EIGENVALUE (OMEGA**2)	NATURAL FREQUENCY	PERIOD	GENERALIZED WEIGHT	MAX TRANSLATION NODE-DOF	MAX TRANSLATION VALUE	--- MODAL WEIGHTS --- (GEN. WGT. * PARTICIPATION FACTORS**2) X1	X2	X3	
1	7231.26	13.534	.0739	2993.15	245-1	1.0000	6171.61779	172.04874	.01637	12.0
2	8652.94	14.975	.0668	3083.53	288-2	1.0000	219.04559	8324.56529	10.26000	12.0
3	9637.89	15.625	.0640	3186.91	294-2	1.0000	15.01414	5.75030	.00565	12.0
4	11532.7	17.092	.0585	2408.31	282-2	1.0000	45.57796	445.13607	.87701	12.0
5	12127.0	17.527	.0571	6293.95	294-1	1.0000	3972.24687	.07653	2.00246	12.0
6	15967.2	20.111	.0497	2765.27	282-2	1.0000	33.67408	.22580	.02216	12.0
7	23263.9	24.275	.0412	1509.93	249-2	1.0000	2.38150	1781.34802	1.78655	12.0
8	23879.4	24.594	.0407	1458.80	251-2	1.0000	4.03740	130.64297	.00080	12.0
9	25037.0	25.183	.0397	4165.00	247-2	1.0000	9.63668	51.70326	.00055	12.0
10	27911.0	26.589	.0376	1776.51	262-2	1.0000	1.46505	461.05116	4.88256	12.0
11	30295.5	27.702	.0361	2276.51	288-2	1.0000	.10111	50.48254	1.19001	12.0
12	30822.1	27.942	.0358	2237.28	219-3	1.0000	.01417	3.04718	146.41327	11.4
13	30886.6	27.971	.0358	2320.38	206-3	1.0000	.00118	.34370	13.11912	10.8
14	31802.6	28.383	.0352	2258.72	232-3	1.0000	.00007	.05804	.00522	9.8
15	31808.5	28.385	.0352	2247.48	214-3	1.0000	.00061	.34395	.00303	9.7
16	33930.1	29.317	.0341	1253.21	227-3	1.0000	.82186	.05898	.02704	10.6
17	34424.5	29.529	.0339	1244.63	201-3	1.0000	.00325	.00000	.01064	8.9
18	36019.5	30.206	.0331	1838.45	266-2	1.0000	.00250	.06441	.23086	7.8
19	37187.1	30.691	.0326	1186.50	227-3	1.0000	.00646	.00603	.01235	7.9
20	37310.5	30.742	.0325	1204.26	193-3	1.0000	.00170	.00430	.01383	8.3

THE FOLLOWING ARE APPROX. EIGENVALUES FOR WHICH MODES WERE NOT REQUESTED.

21	41933.9	32.591	8.4
22	44421.4	33.544	7.7
23	47024.0	34.513	7.5

LANCZOS REDUCED MATRIX SIZE (DOF) = 58
APPROX. MAXIMUM EIGENVALUE(OMEGA**2)= .305324E+08

NOTE THE LAST COLUMN IN THE TABLE ABOVE IS RELATED TO EIGENVALUE ACCURACY BOUNDS.

Figure 7.2 Natural Frequencies of Five-Bay LC-25 Battery Rack

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	TWO-BAY		FIVE-BAY	
COMPONENT	BEAM	STRESS (PSI)	BEAM	STRESS (PSI)
Frame	48	34,068	102	33,179
Support Rail	99	3,883	249	3,861
Side Rail	104	9,453	260	9,620
Brace	131	6,061	314	4,957

TABLE 5 Comparison of Member Stresses for Two-bay and Five-bay Battery Rack

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7.3 Biaxial Testing

Seismic qualification of the LC-21 battery racks are based on previous seismic test programs which used biaxial seismic input. A series of biaxial tests simulates simultaneous input in all three principal directions if the test specimen has little or no cross sensitivity ti input motion.

It has been demonstrated by the analyses in Reference 4 that there is a minimum of cross coupling effects in the battery rack structure. The results of the analyses contained in Figures 7.1 and 7.2 show the modal weights in each principal direction for each mode. There is no significant modal weight acting in more than one direction for any one mode shape. Therefore, in the frequency range of interest, there is no significant cross coupling of input motion for iether the two-bay or the multi-bay rack models, and will be true for all two step seismic racks models of identical design.

Since the battery racks have no cross sensitivity to input motion, biaxial seismic testing is justified for the racks.

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Telelype: 510-660-8436

8.0 LIST OF REFERENCES

1. Arkansas Power & Light Purchase Order No. 01013 and Supplements 1, 2, and 3

2. Arkansas Power & Light Form 102F6, Rev. 12-7-82, Conditions of Acceptance

3. Arkansas Power & Light Specification No. AP &L-C-502, Rev. 1, Tehcnical Specifications for Earthquake Resistance Design of Equipment

4. Lehrman, S.A. and Dr. Yow, J.R., CCL Report No. A-379-81-01, "Seismic Qualification Reoprt of DCU-5, KC-19 and LC-25 Battery Racks and Cells for Susquehanna S.E.S. Units 1 & 2, 20 May 82

5. Wyle Laboratories, Seismic Simulation Test Report No. 43450-1, 7 Dec 76, "Seismic Simulation Test Program on a Battery Rack and Batteries"

6. **IEEE Std 323-1974: IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations**

7. **IEEE Std 344-1975: IEEE Recommended Practices for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations**

8. **IEEE Std 450-1980: IEEE Recommended Practices for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations**

9. **IEEE Std 484-1981: IEEE Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations**

10. **IEEE Std 535-1979: IEEE Standard for Qualification of Class IE Lead Storage Batteries for Nuclear Power Generating Stations**

ATTACHMENT 1

(3 pages)

BATTERY SIZING WORKSHEET

Reference: IEEE Std 485-1979
SIZED BY: GW
DATE: 17 MAR 84

PROJECT: ARKANSAS NUCLEAR ONE - BATTERY D06

LOWEST DESIGN TEMPERATURE	77°F	MINIMUM DESIGN CELL VOLTAGE	1.81	SIZING BASIS: PLATE NOMENCLATURE	LC

LOAD PERIOD	LOAD (AMPERES)	CHANGE IN LOAD (AMPERES) + values	CHANGE IN LOAD (AMPERES) - values	DURATION: OF LOAD PERIOD (MINUTES)	TIME TO END OF SECTION (MINUTES)	CAPACITY: AMPERES PER POS PLATE LCR	REQUIRED SECTION CELL SIZE POSITIVE PLATES + values	REQUIRED SECTION CELL SIZE POSITIVE PLATES - values
SECTION 1 - First Period Only - If 2 is greater than 1, go to SECTION 2								
1	829	829		1	1	110 115	7.54	
						Sec. 1 Total	7.54	
SECTION 2 - First 2 Periods Only - If 3 is greater than 2, go to SECTION 3								
1	829	829		1	3	108.5 112	7.64	
2	659		170	2	2	109 113		1.56
						Sec. 2 Sub Tot.	7.64	1.56
						Total	6.08	
SECTION 3 - First 3 Periods Only - If 4 is greater than 3, go to SECTION 4								
1	829	829		1	30	80	10.32	
2	659		170	2	29	80		2.12
3	609		50	27	27	81		.62
						Sec. 3 Sub Tot.	10.32	2.74
						Total	7.58	
RANDOM EQUIPMENT LOAD(S) (AS APPLICABLE)								

(For sizing SECTIONS 4 thru 8, use reverse side)

MAXIMUM SECTION SIZE	7.58
+ RANDOM LOAD SIZE	N/A
= BASE DESIGN SIZE	7.58
BASE DESIGN MULTIPLIERS: × TEMPERATURE CORRECTION	1.00
× DESIGN MARGIN	1.00
× AGING FACTOR	1.25
= NUMBER OF POSITIVE PLATES	9.47

REQUIRED CELL SIZE: 10 POSITIVE PLATES

REQUIRED CELL MODEL: LC-21

LOAD PERIOD	LOAD (AMPERES)	CHANGE IN LOAD (AMPERES) + values	CHANGE IN LOAD (AMPERES) - values	DURATION: OF LOAD PERIOD (MINUTES)	TIME TO END OF SECTION (MINUTES)	CAPACITY: AMPERES PER POS PLATE	REQUIRED SECTION CELL SIZE POSITIVE PLATES + values	REQUIRED SECTION CELL SIZE POSITIVE PLATES - values
SECTION 4 - First 4 Periods Only - If 5 is greater than 4, go to SECTION 5								
1	829	829		1	120	45.5	18.22	
2	659		170	2	119	45.5		3.74
3	609		50	27	117	45.5		1.10
4	115		494	90	90	53.0		9.32
						Sec. 4 Sub Tot.	18.22	14.16
						Total	4.06	
SECTION 5 - First 5 Periods Only - If 6 is greater than 5, go to SECTION 6								
						Sec. 5 Sub Tot.		
						Total		
SECTION 6 - First 6 Periods Only - If 7 is greater than 6, go to SECTION 7								
1	829	829		1	240	29	28.58	
2	659		170	2	239	29		5.86
3	609		50	27	237	29		1.72
4	115		494	90	210	32		15.44
5	37		78	119	120	45		1.73
6	187	150		1	1	110	1.36	
						Sec. 6 Sub Tot.	29.94	24.75
						Total	5.19	
SECTION 7 - First 7 Periods Only - If 8 is greater than 7, go to SECTION 8								
						Sec. 7 Sub Tot.		
						Total		
SECTION 8 - First 8 Periods Only - If 9 is greater than 8, go to SECTION 9								
						Sec. 8 Sub Tot.		
						Total		

SIDE 2 of "D06"

BATTERY SIZING WORKSHEET

Reference: IEEE Std 485-1979
SIZED BY: GW
DATE: 17 MAR 84

PROJECT: ARKANSAS NUCLEAR ONE - BATTERY D07

LOWEST DESIGN TEMPERATURE	77°F	MINIMUM DESIGN CELL VOLTAGE	1.81	SIZING BASIS: PLATE NOMENCLATURE	LC

LOAD PERIOD	LOAD (AMPERES)	CHANGE IN LOAD (AMPERES) + values	CHANGE IN LOAD (AMPERES) - values	DURATION: OF LOAD PERIOD (MINUTES)	TIME TO END OF SECTION (MINUTES)	CAPACITY: AMPERES PER POS PLATE	REQUIRED SECTION CELL SIZE POSITIVE PLATES + values	REQUIRED SECTION CELL SIZE POSITIVE PLATES - values
SECTION 1 - First Period Only - If 2 is greater than 1, go to SECTION 2								
1	797	797		1	1	110	7.24	
						Sec. 1 Total	7.24	
SECTION 2 - First 2 Periods Only - If 3 is greater than 2, go to SECTION 3								
1	797	797		1	3	108.5	7.34	
2	627		170	2	2	109		1.56
						Sec. 2 Sub Tot.	7.34	1.56
						Total	5.78	
SECTION 3 - First 3 Periods Only - If 4 is greater than 3, go to SECTION 4								
1	797	797		1	30	80	9.96	
2	627		170	2	29	80		2.12
3	577		50	27	27	81		.62
						Sec. 3 Sub Tot.	9.96	2.74
						Total	7.22	
RANDOM EQUIPMENT LOAD(S) (AS APPLICABLE)								

(For sizing SECTIONS 4 thru 8, use reverse side)

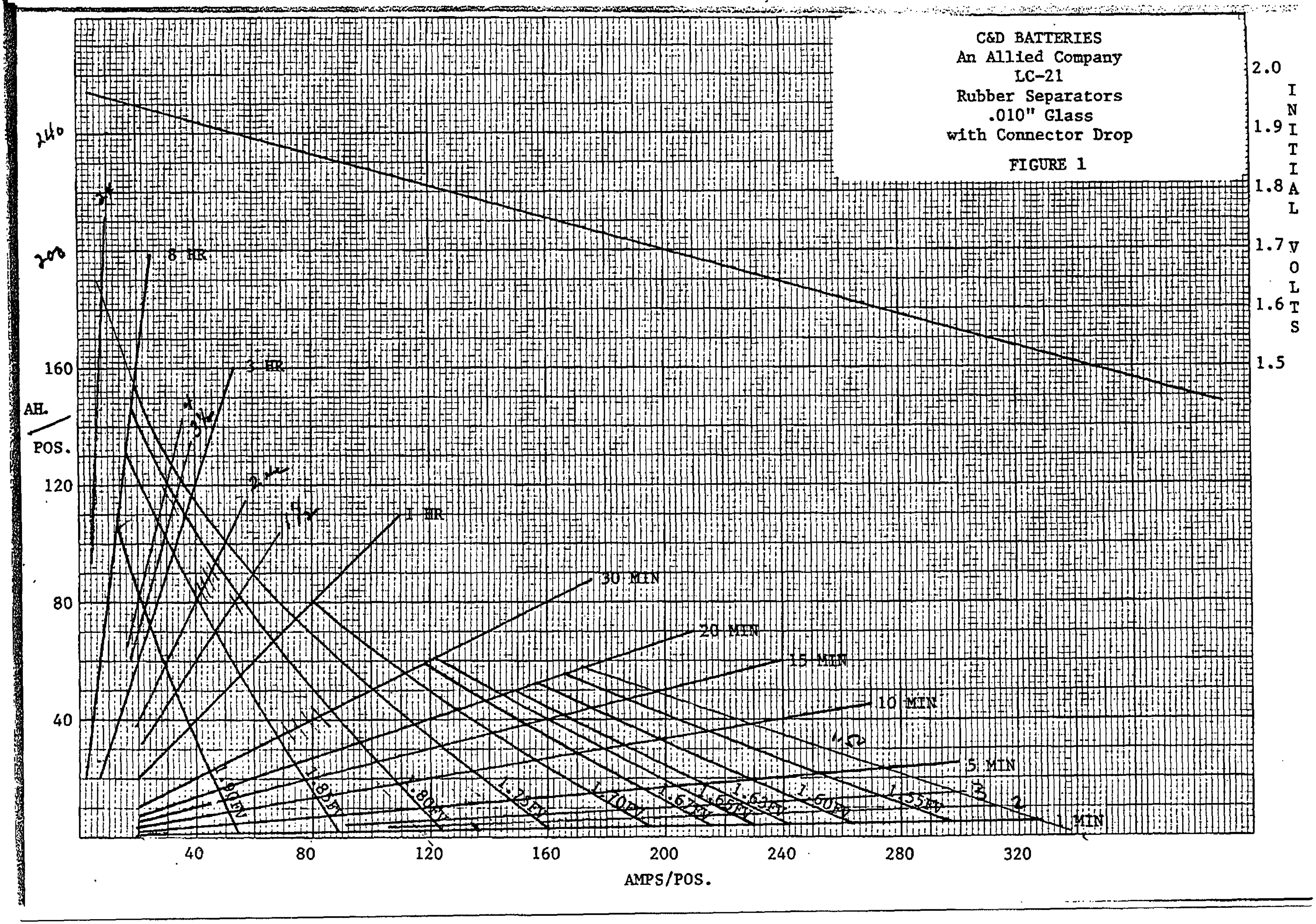
MAXIMUM SECTION SIZE	7.93	+ RANDOM LOAD SIZE	N/A
		= BASE DESIGN SIZE	7.93
BASE DESIGN MULTIPLIERS:		× TEMPERATURE CORRECTION	1.00
		× DESIGN MARGIN	1.00
		× AGING FACTOR	1.25
		= NUMBER OF POSITIVE PLATES	9.91

REQUIRED CELL SIZE: 10 POSITIVE PLATES

REQUIRED CELL MODEL: LC-21

Side 2 of "DO7"

LOAD PERIOD	LOAD (AMPERES)	CHANGE IN LOAD (AMPERES) + values	CHANGE IN LOAD (AMPERES) - values	DURATION: OF LOAD PERIOD (MINUTES)	TIME TO END OF SECTION (MINUTES)	CAPACITY: AMPERES PER POS PLATE	REQUIRED SECTION CELL SIZE POSITIVE PLATES + values	REQUIRED SECTION CELL SIZE POSITIVE PLATES - values
SECTION 4 - First 4 Periods Only - If 5 is greater than 4, go to SECTION 5								
1	797	797		1	120	45.5	17.52	
2	627		170	2	119	45.5		3.74
3	577		50	27	117	45.5		1.10
4	325		252	90	90	53.0		4.75
						Sec. 4 Sub Tot.	17.52	9.59
						Total	7.93	
SECTION 5 - First 5 Periods Only - If 6 is greater than 5, go to SECTION 6								
						Sec. 5 Sub Tot.		
						Total		
SECTION 6 - First 6 Periods Only - If 7 is greater than 6, go to SECTION 7								
1	797	797		1	240	29	27.48	
2	627		170	2	239	29		5.86
3	577		50	27	237	29		1.72
4	325		252	90	210	32		7.87
5	47		278	119	120	45		6.18
6	197	150		1	1	110	1.36	
						Sec. 6 Sub Tot.	28.84	21.63
						Total	7.21	
SECTION 7 - First 7 Periods Only - If 8 is greater than 7, go to SECTION 8								
						Sec. 7 Sub Tot.		
						Total		
SECTION 8 - First 8 Periods Only - If 9 is greater than 8, go to SECTION 9								
						Sec. 8 Sub Tot.		
						Total		

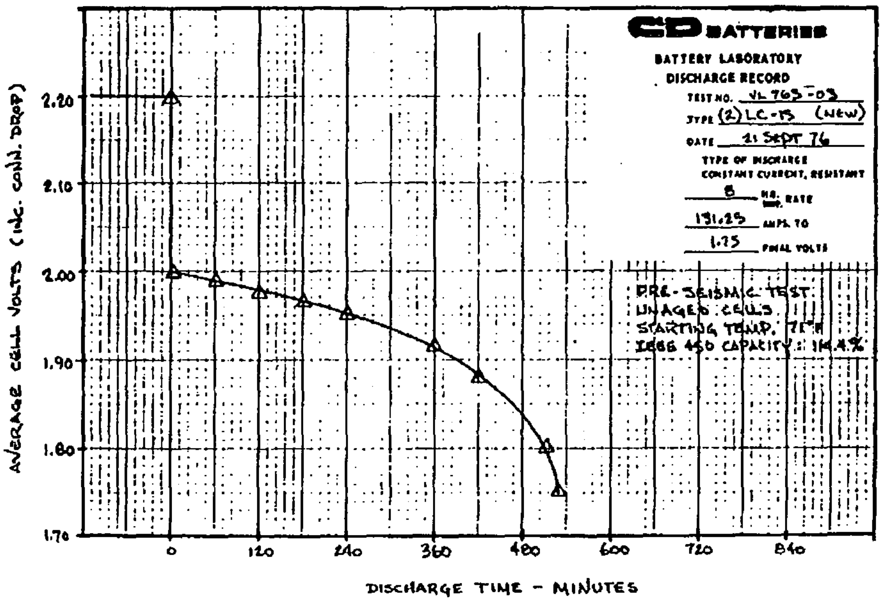


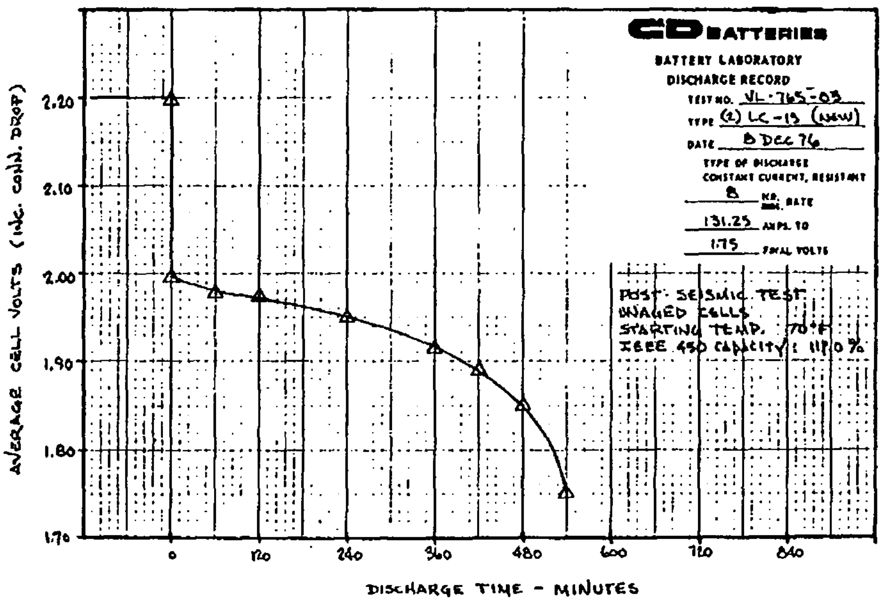
C&D BATTERIES
An Allied Company
LC-21
Rubber Separators
.010" Glass
with Connector Drop
FIGURE 1
8 HR
3 HR
1 HR
30 MIN
20 MIN
15 MIN
10 MIN
5 MIN
1 MIN
1.90FV
1.85FV
1.80FV
1.75FV
1.70FV
1.67FV
1.65FV
1.63FV
1.60FV
1.55FV
AH./POS.
160
120
80
40
AMPS/POS.
40
80
120
160
200
240
280
320
INITIAL VOLTS
2.0
1.9
1.8
1.7
1.6
1.5

ATTACHMENT 2

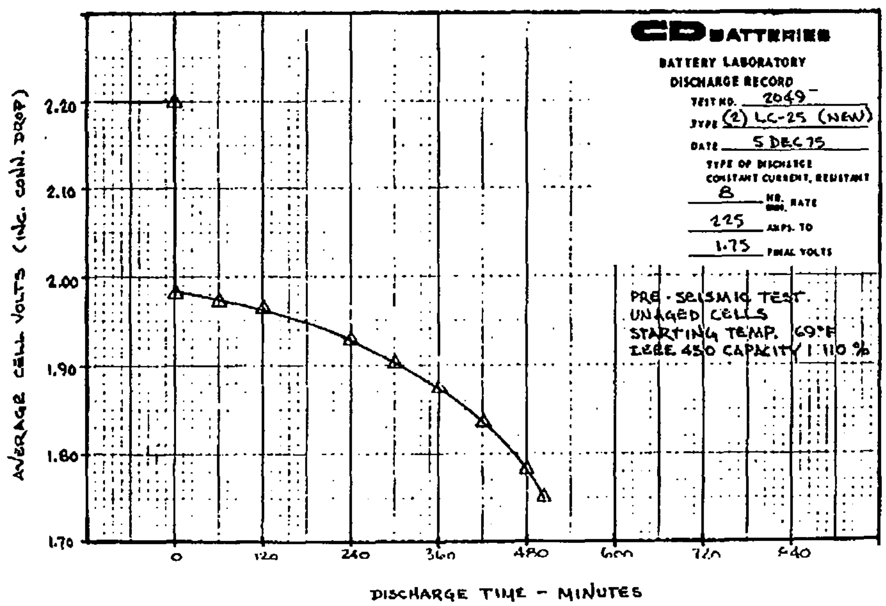
(8 pages)

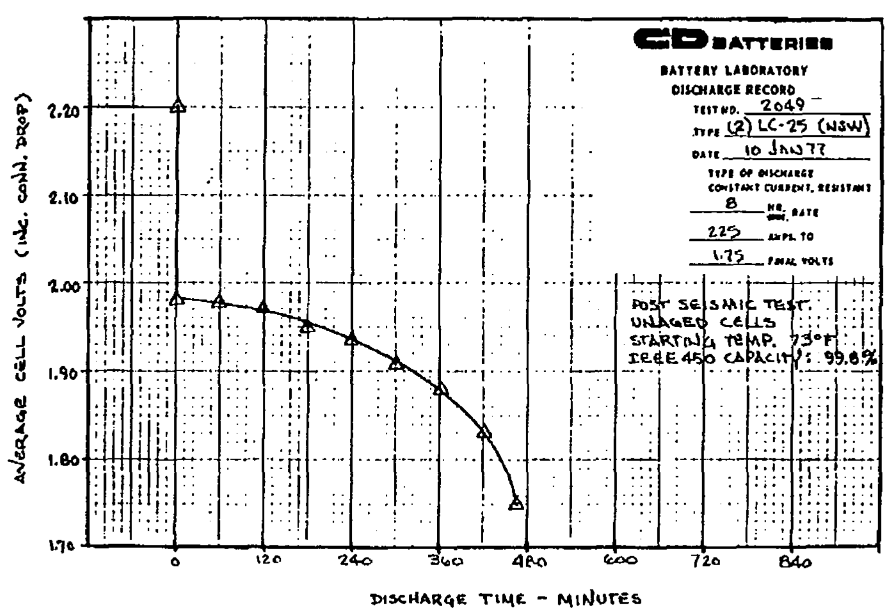
C&D BATTERIES



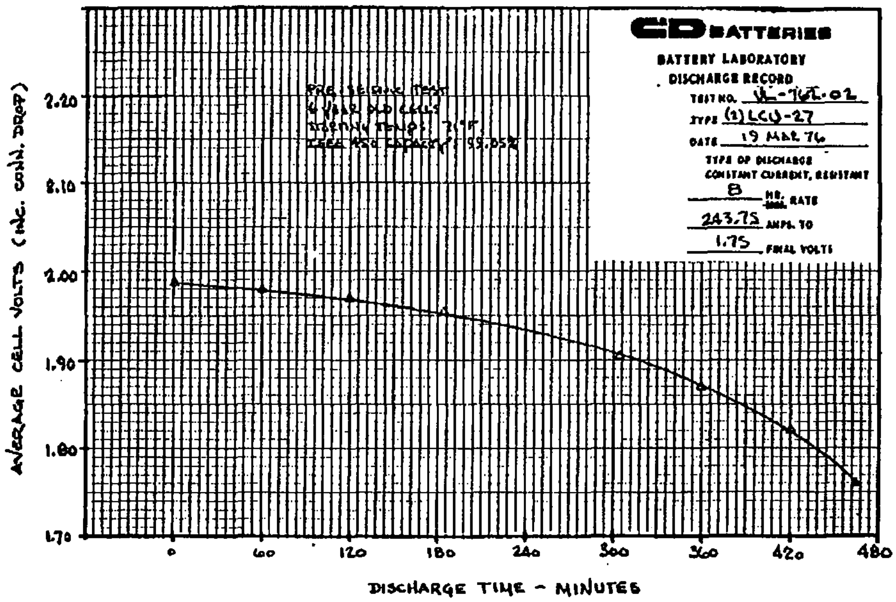


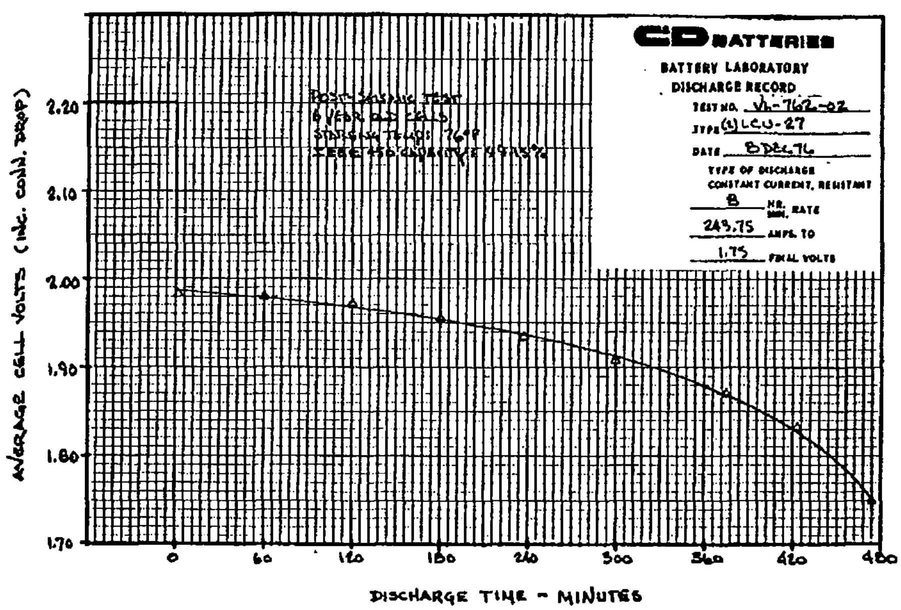
C&D BATTERIES



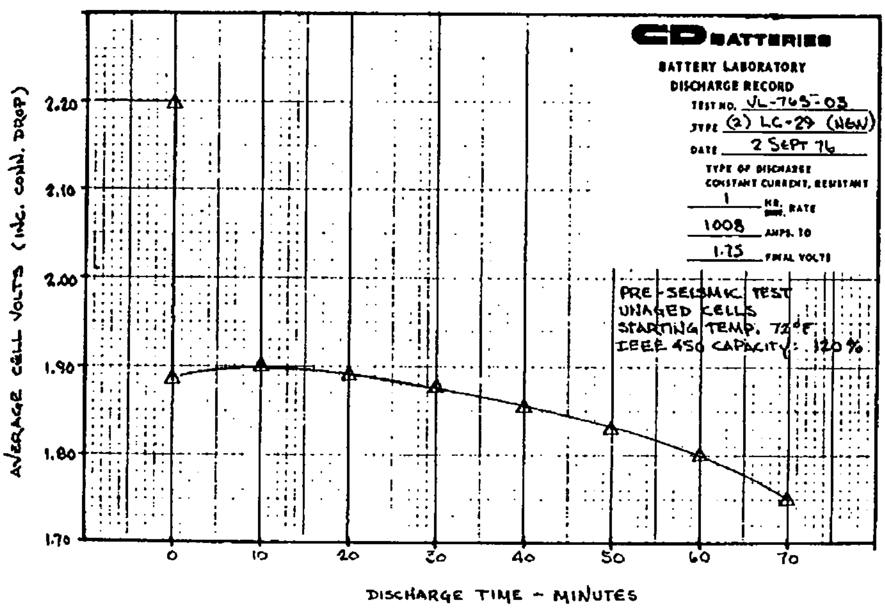


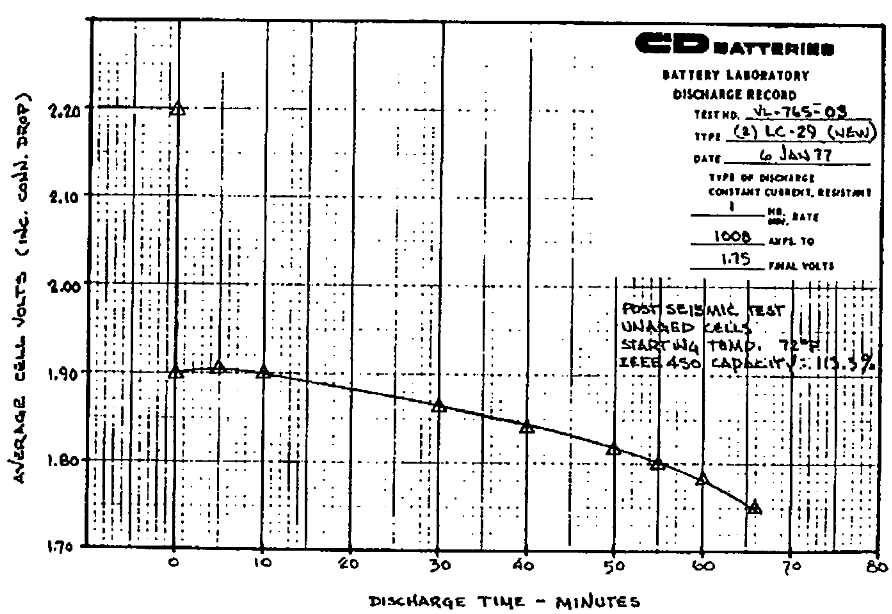
C&D Batteries



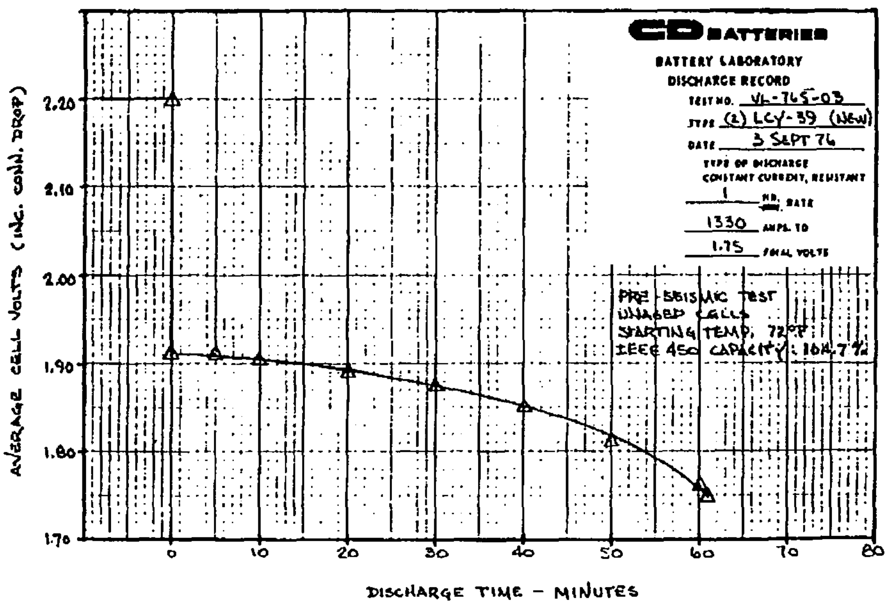


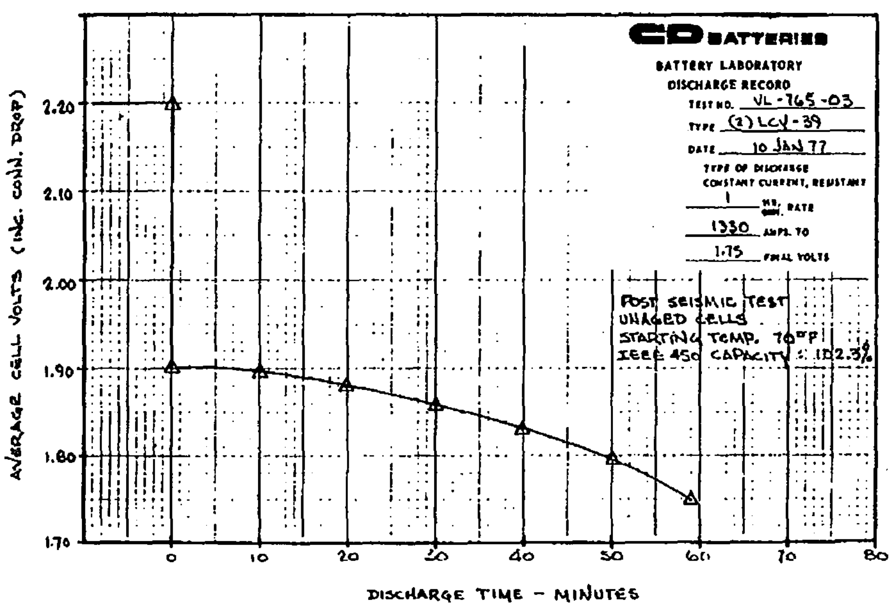
C&D BATTERIES



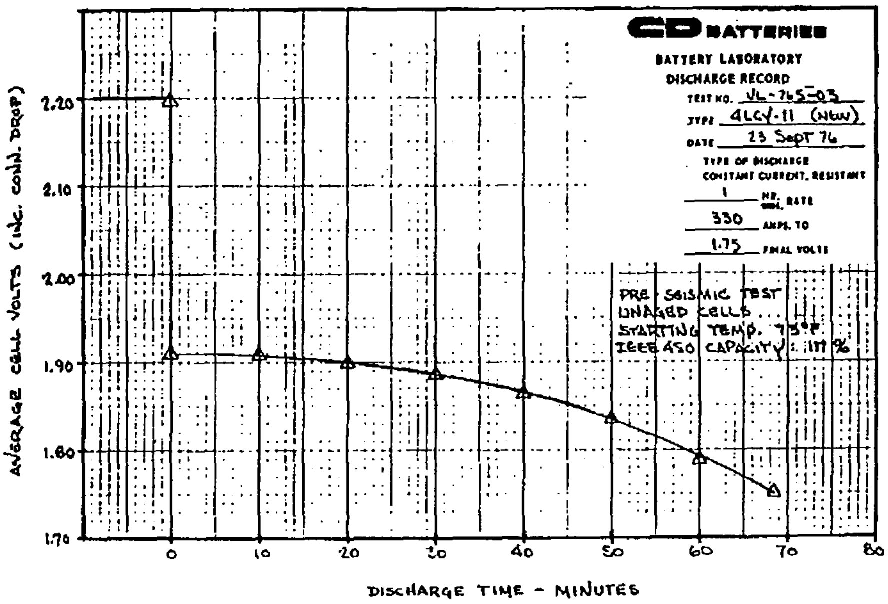


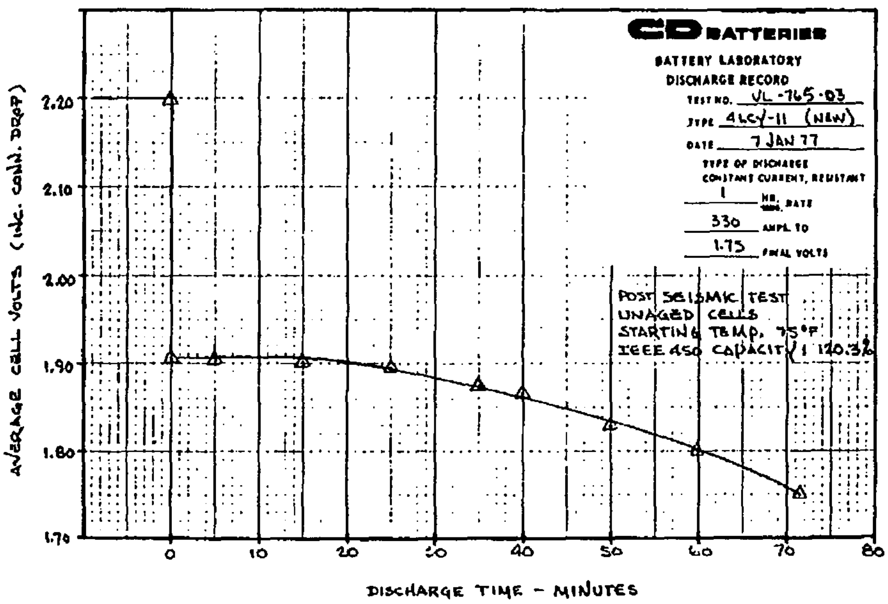
C&D BATTERIES



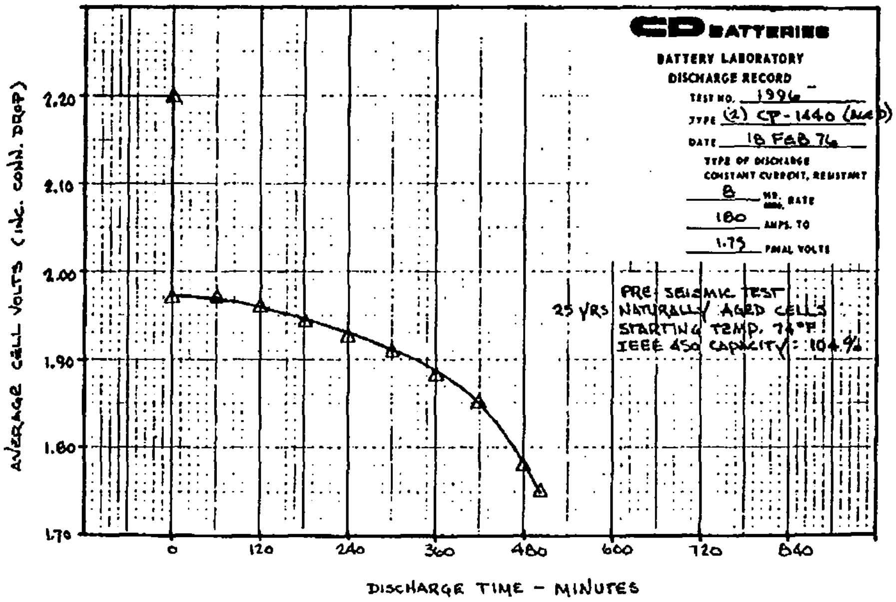


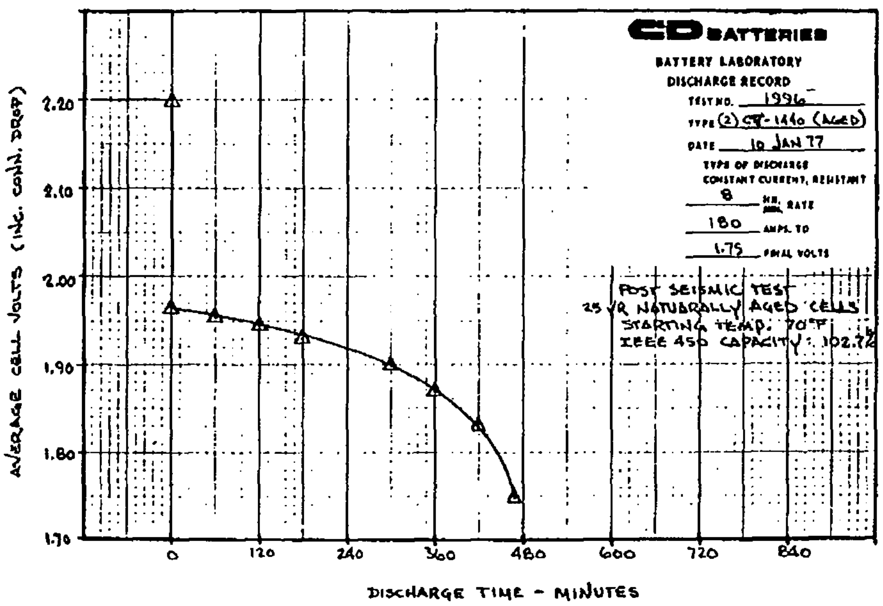
C&D BATTERIES





C&D BATTERIES





INSTRUMENTATION EQUIPMENT SHEET

Date AS APPLICABLE TO TEST Job No. N.A. Test Area BATTERY LAB

Technician VARIOUS LAB PERSONNEL Customer N.A. Type Test CAPACITY DISCHARGE

No.	Instrument	Manufacturer	Model No.	Serial No.	Range	Accuracy	Calibration On	Calibration Due
1	DIGITAL MILLIVOLTMETER	UNITED SYSTEMS CORP DIGITEC			0-100 MV	± 1/2 %	CALIBRATED AT 6 MO. INTERVALS	
2	DIGITAL VOLTMETER	"			0-10 VOLTS	± 1/2 %	"	
3	DISCHARGE BANK (POWER SINK)	METRODYNAMICS	251-1	8178	0-200 AMPS	± 2%	"	
4	METER SHUNT	WESTON	—	—	50 MV DROP	± 1/2 %	"	
5	OSCILLOGRAPH	HONEYWELL	1912	75048	2.5 KHz	± 4 %	"	
6	DATA LOGGER	CONSOLIDATED CONTROLS CORP.	90MC 1-9	5498ML	-3.3 TO +3.3 VOLTS		"	
7	DATA LOGGER	UNITED SYSTEMS CORP DIGITEC	1000A	22680850	-3.3 TO +3.3 VOLTS		"	

ATTACHMENT 3

(28 pages)

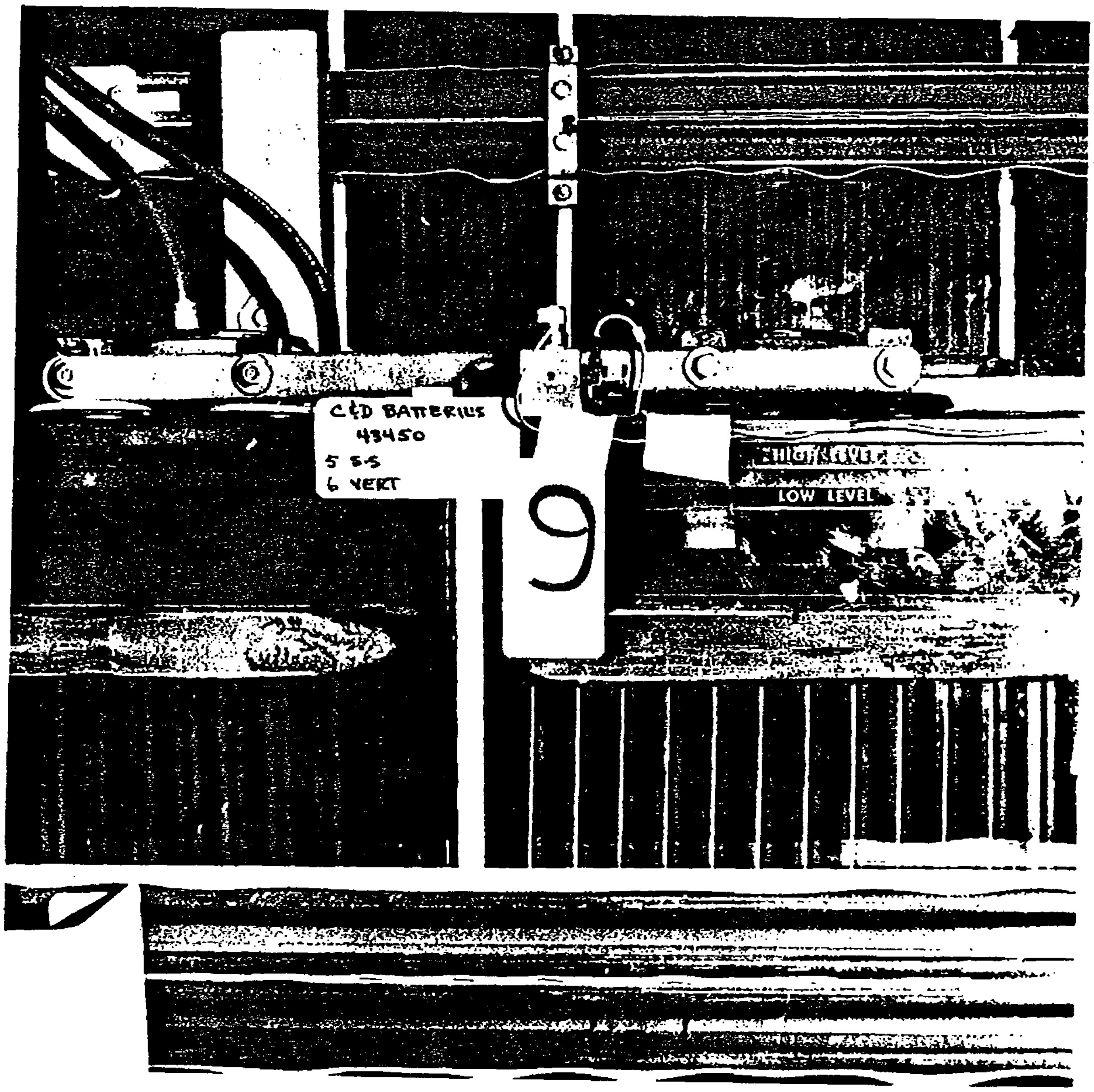
APPENDIX I

TRANSMISSIBILITY PLOTS

TEST NO.	AXES
1	SS/V
9	FB/V

PHOTOGRAPH 2

LOCATIONS OF ACCELEROMETERS 1, 2, 3 AND 4

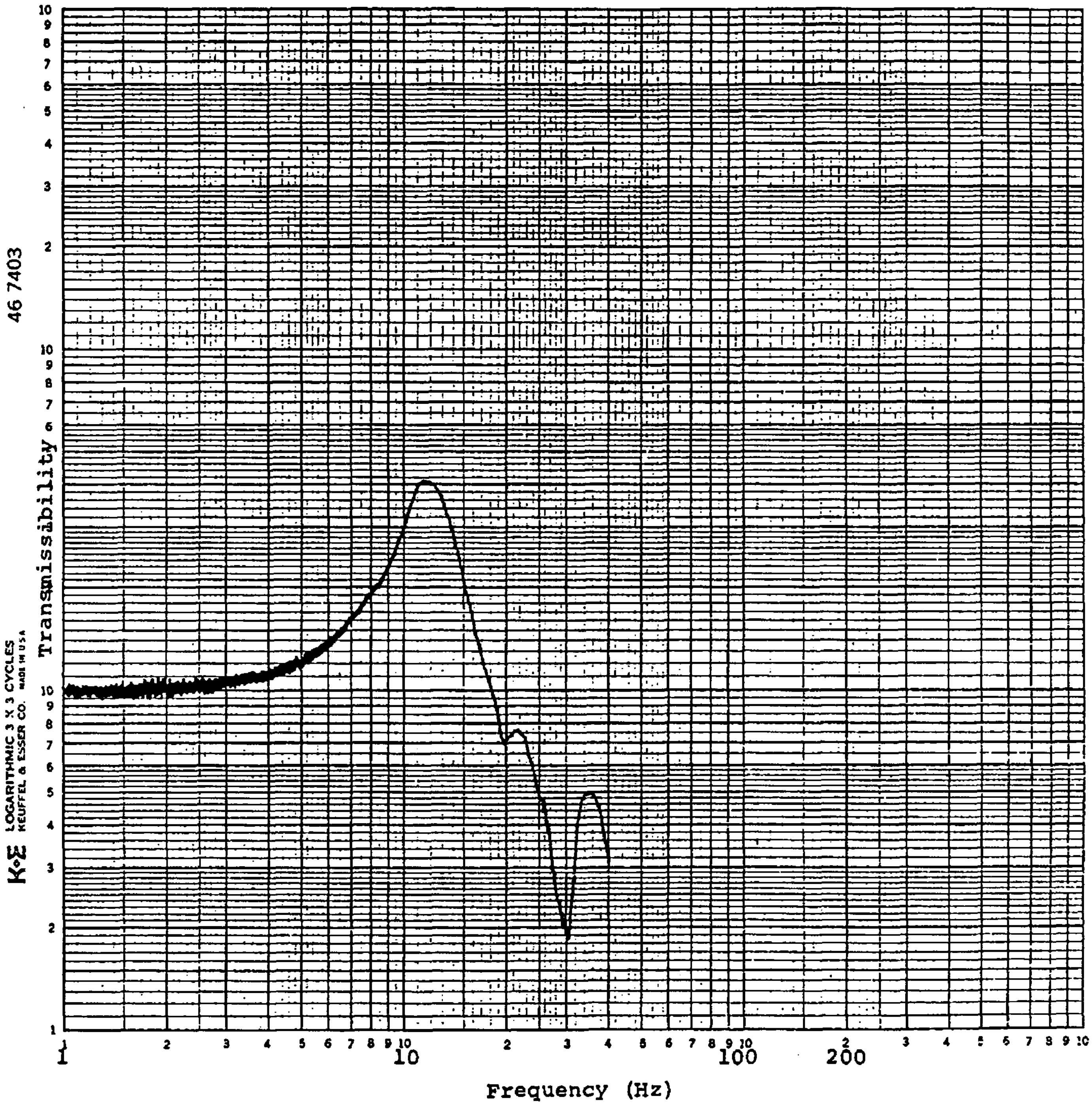


PHOTOGRAPH 3

LOCATIONS OF ACCELEROMETERS 5 AND 6

FULL SCALE TRANSMISSIBILITY

0.1 ☐   1.0 ☐   10 ☐   100 ☒   1000 ☐



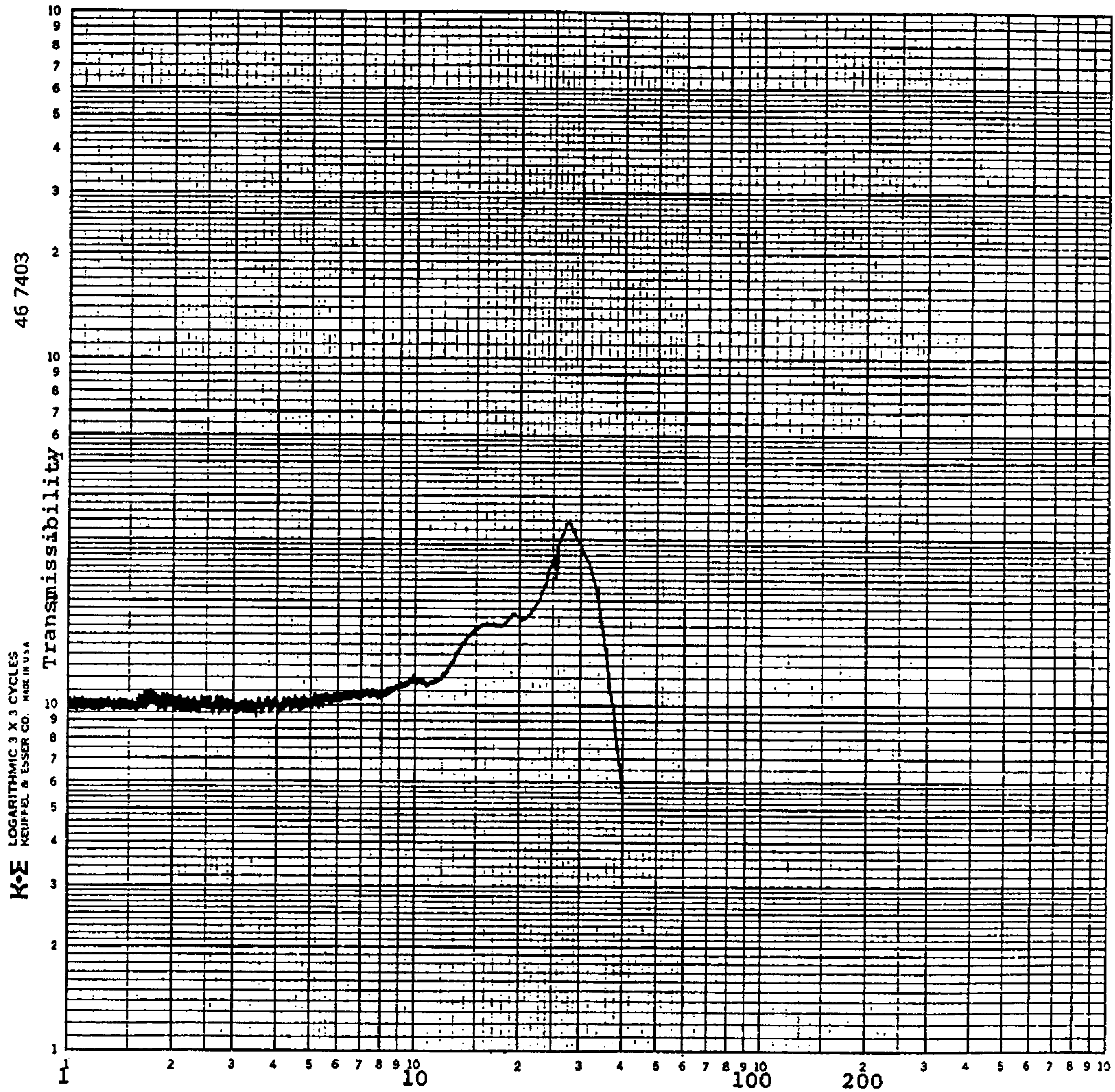
AXIS 5.5/VERT

ACCEL. NO. 15.5 ÷ NO. HCA

TEST RUN NO. 1

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



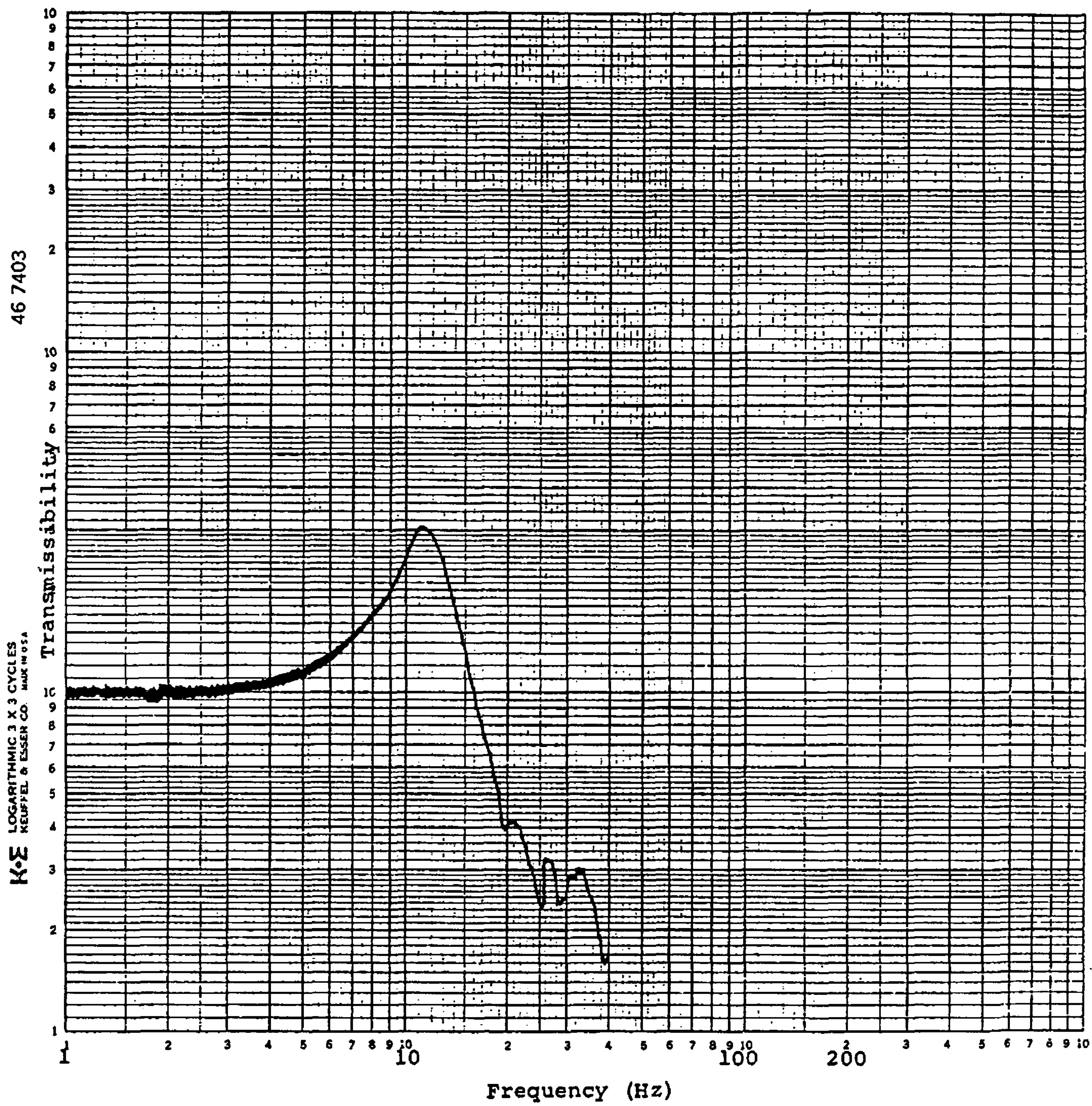
AXIS S·S | VERT

ACCEL. NO. ZV ÷ NO. VCA

TEST RUN NO. 1

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



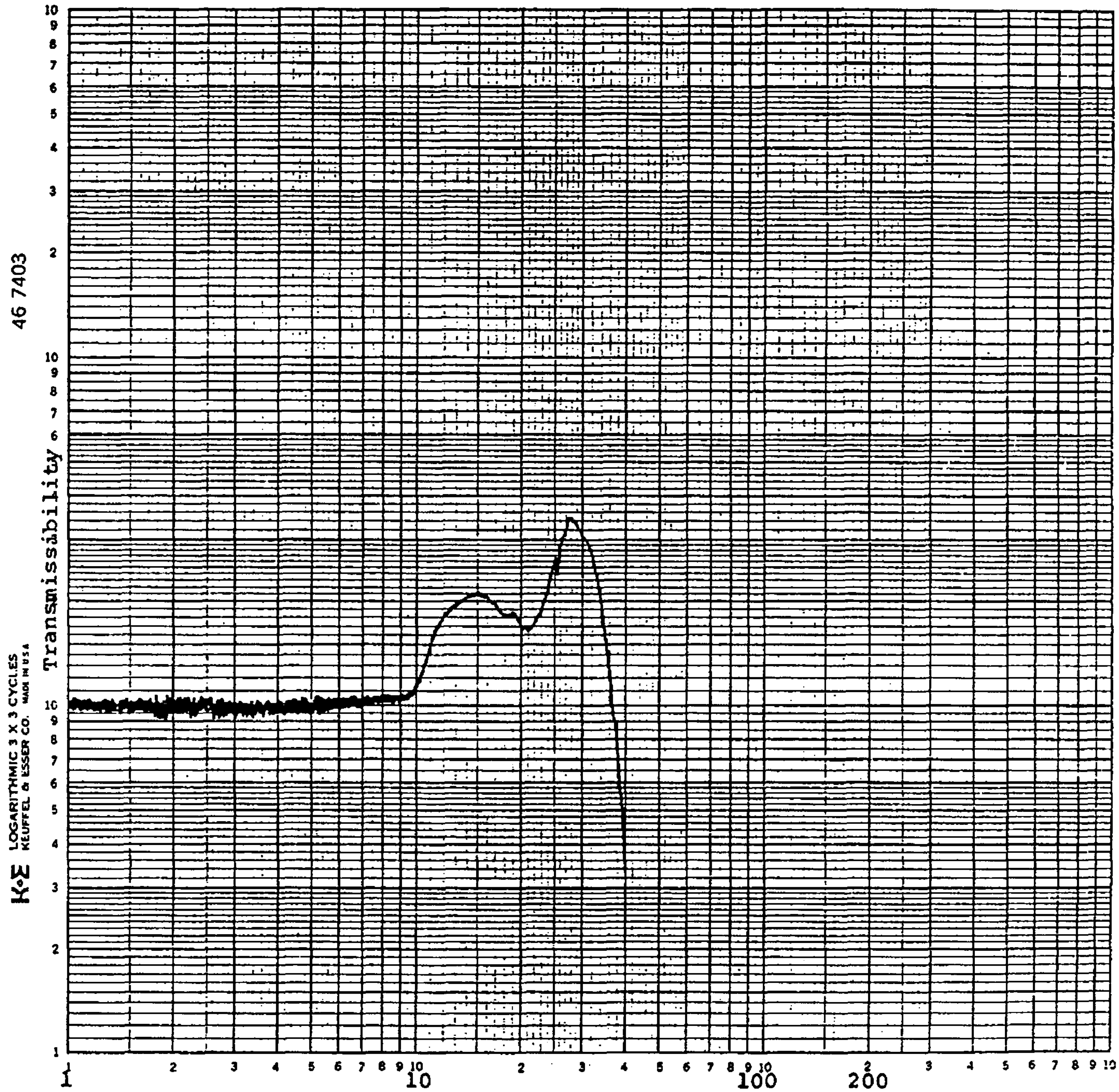
AXIS S-S/VERT

ACCEL. NO. 3S.S ÷ NO. HCA

TEST RUN NO. 1

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



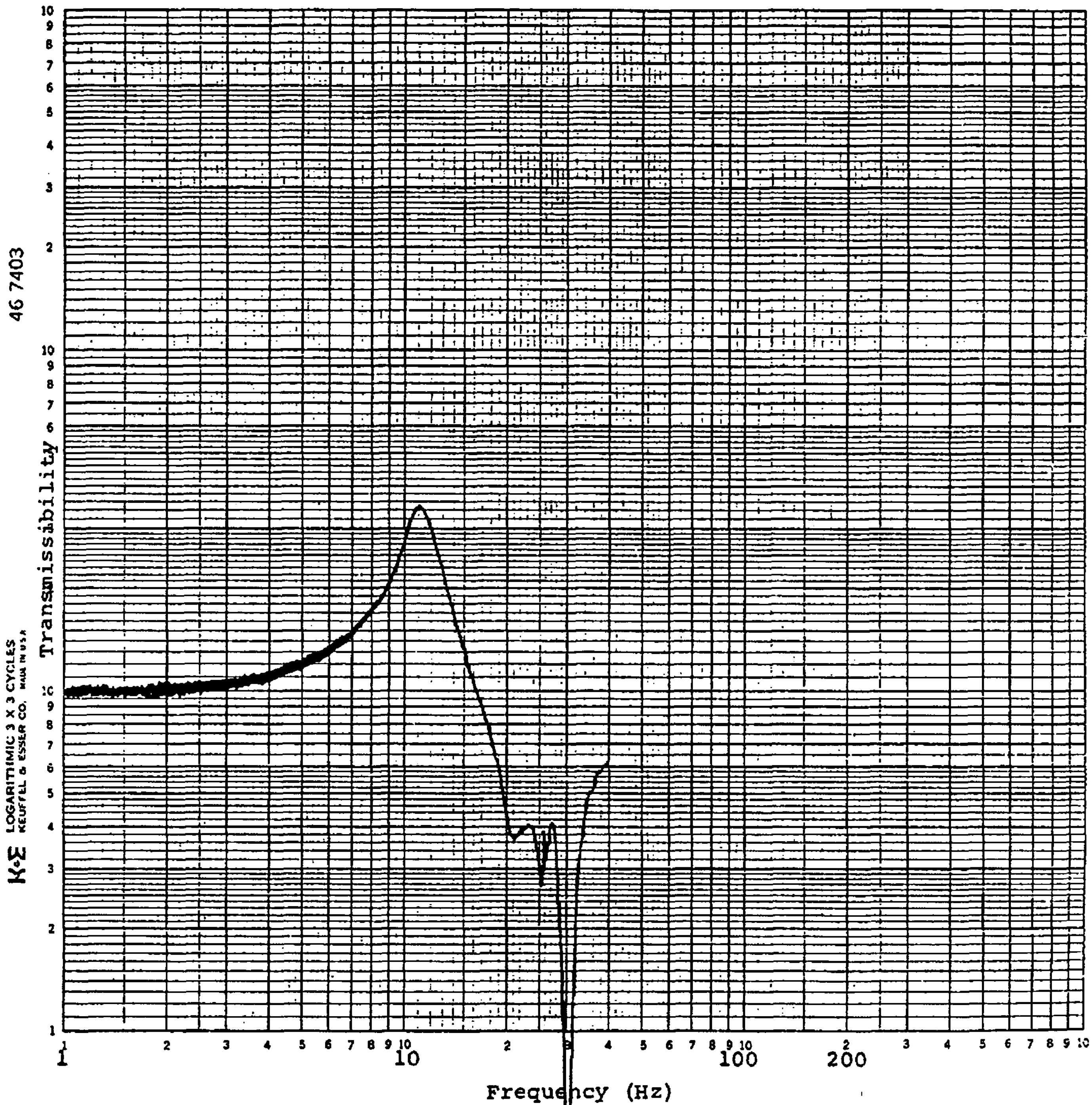
AXIS S-S/VERT

ACCEL. NO. HV ÷ NO. VCA

TEST RUN NO. 1

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



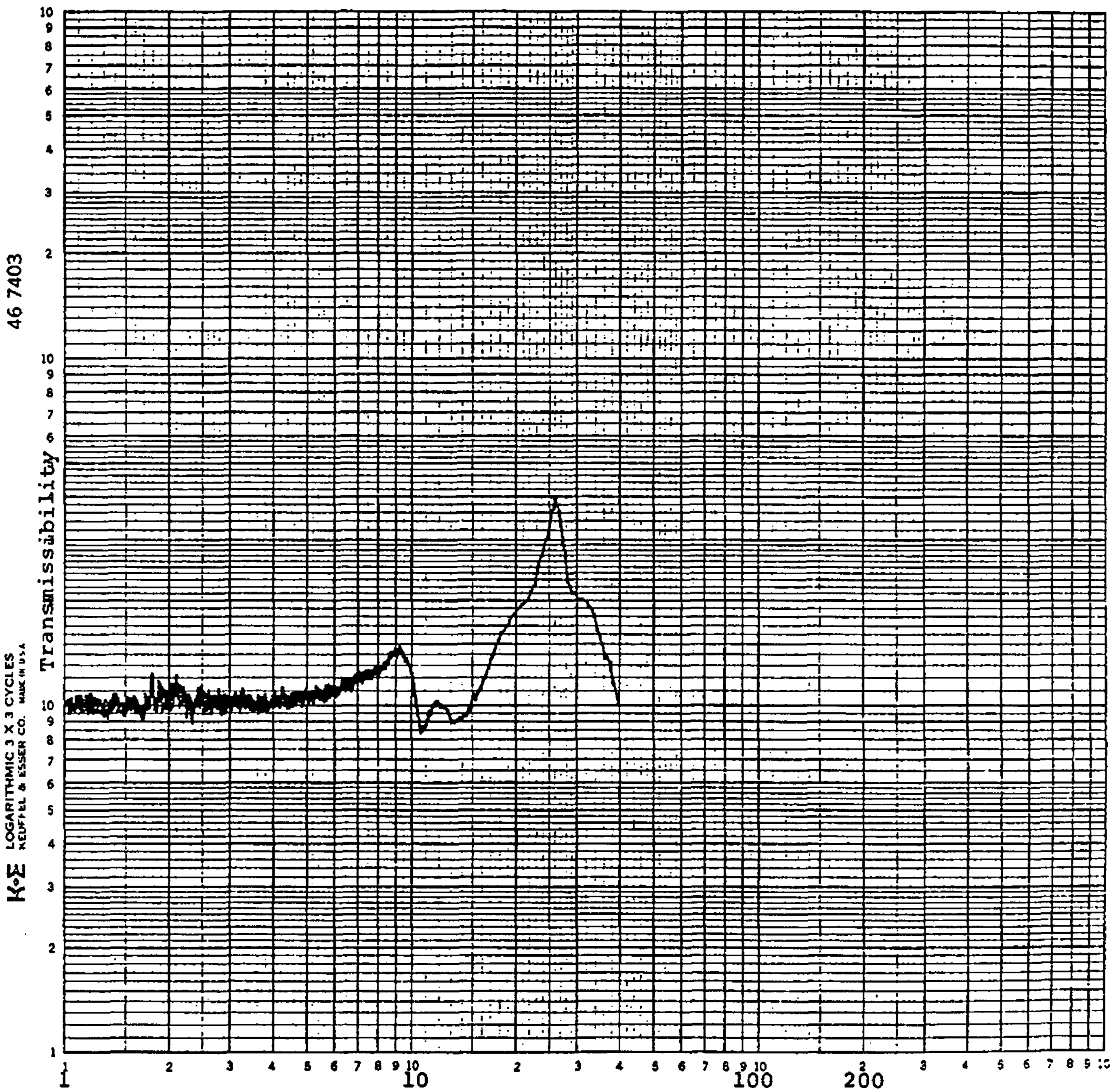
AXIS S-S VERT

ACCEL. NO. 55.5 ÷ NO. HCA

TEST RUN NO. 1

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



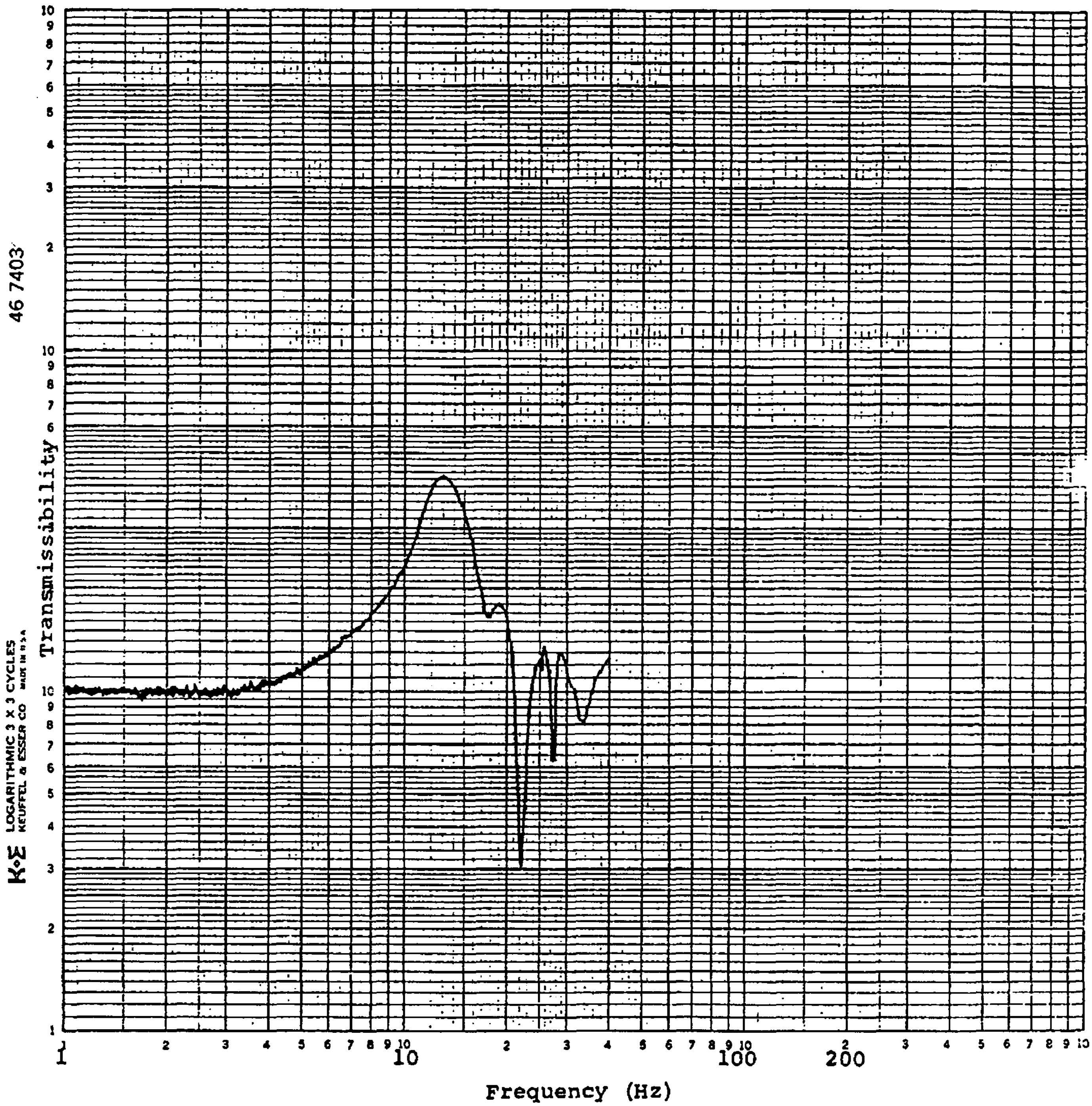
AXIS S-S/VERT

ACCEL. NO 6V ÷ NO. VCA

TEST RUN NO. 1

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



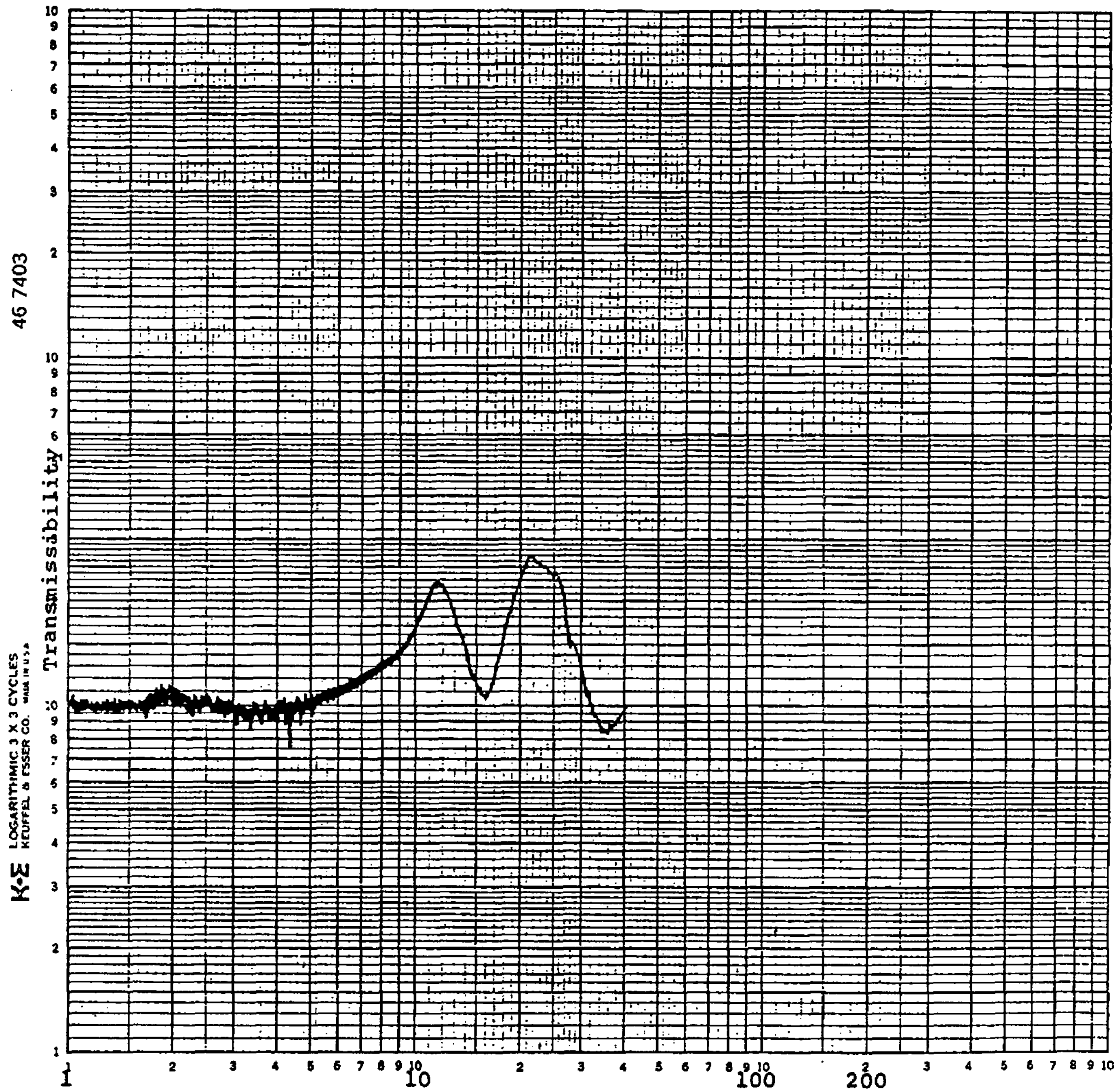
AXIS F-B/VERT

ACCEL. NO. 1FB ÷ NO. HCA

TEST RUN NO. 9

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



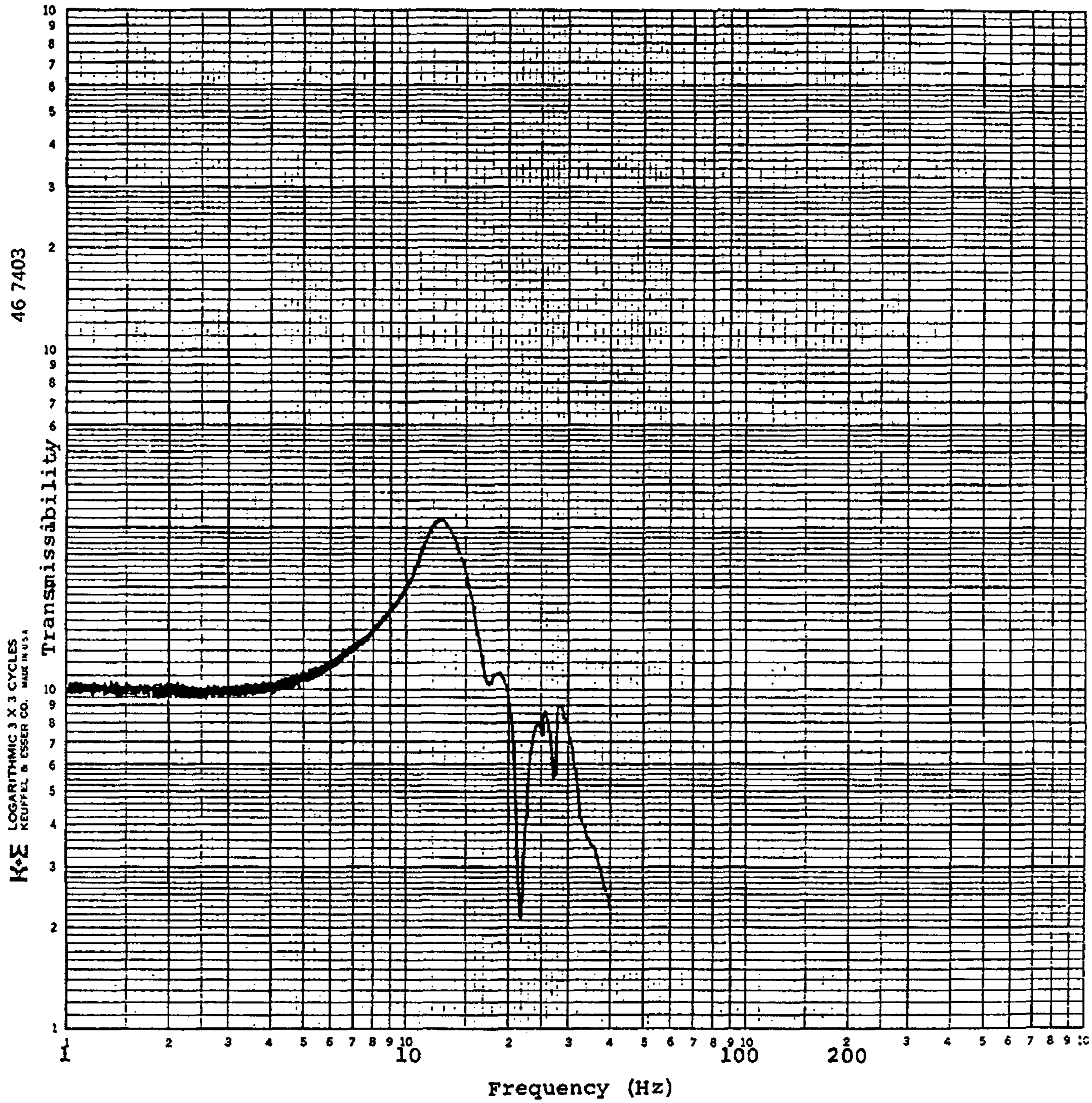
AXIS F-B / VERT

ACCEL. NO. 2V ÷ NO. VCA

TEST RUN NO. 9

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



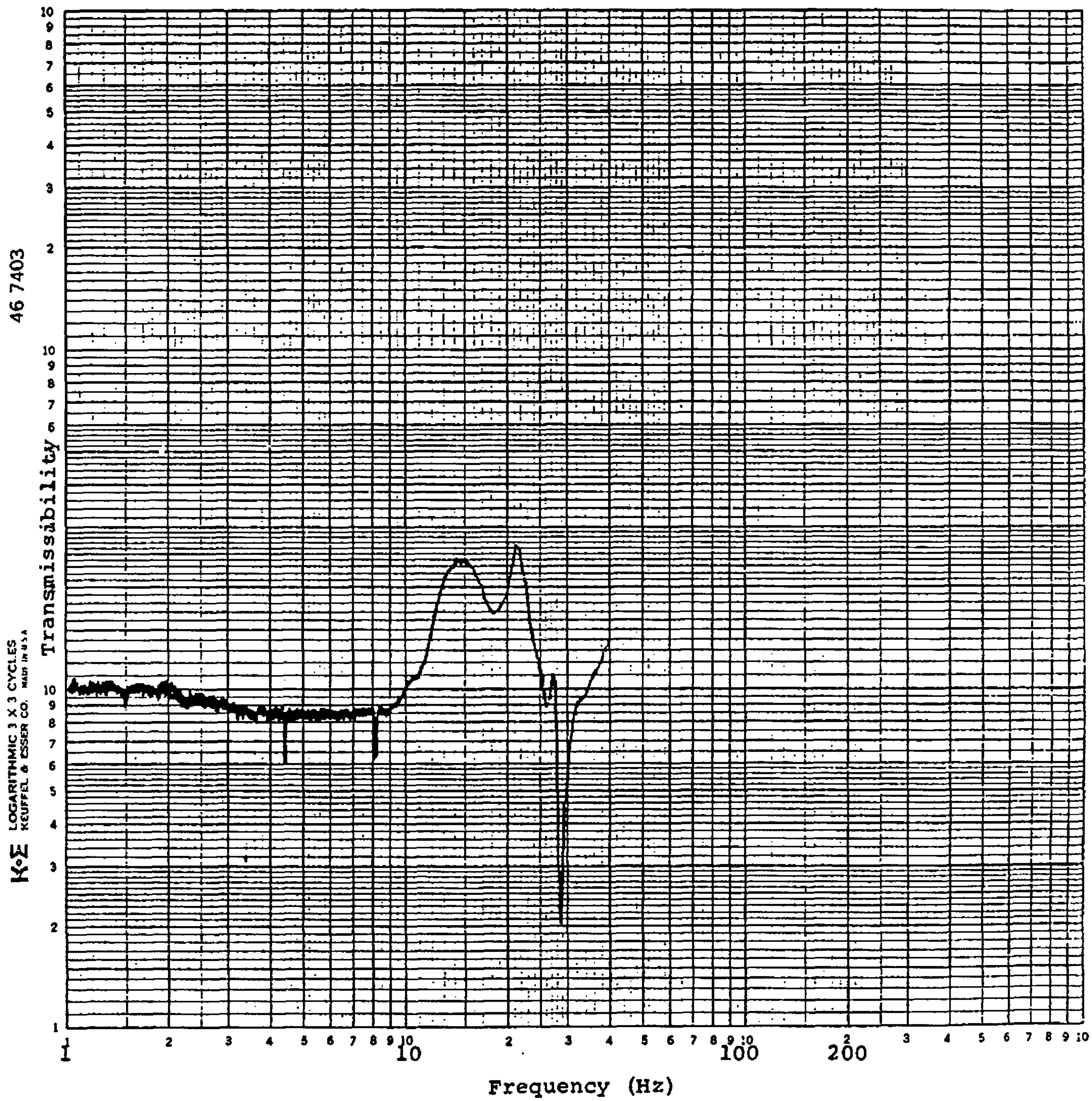
AXIS F-B / VERT

ACCEL. NO. 3FB ÷ NO. HCA

TEST RUN NO. 9

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



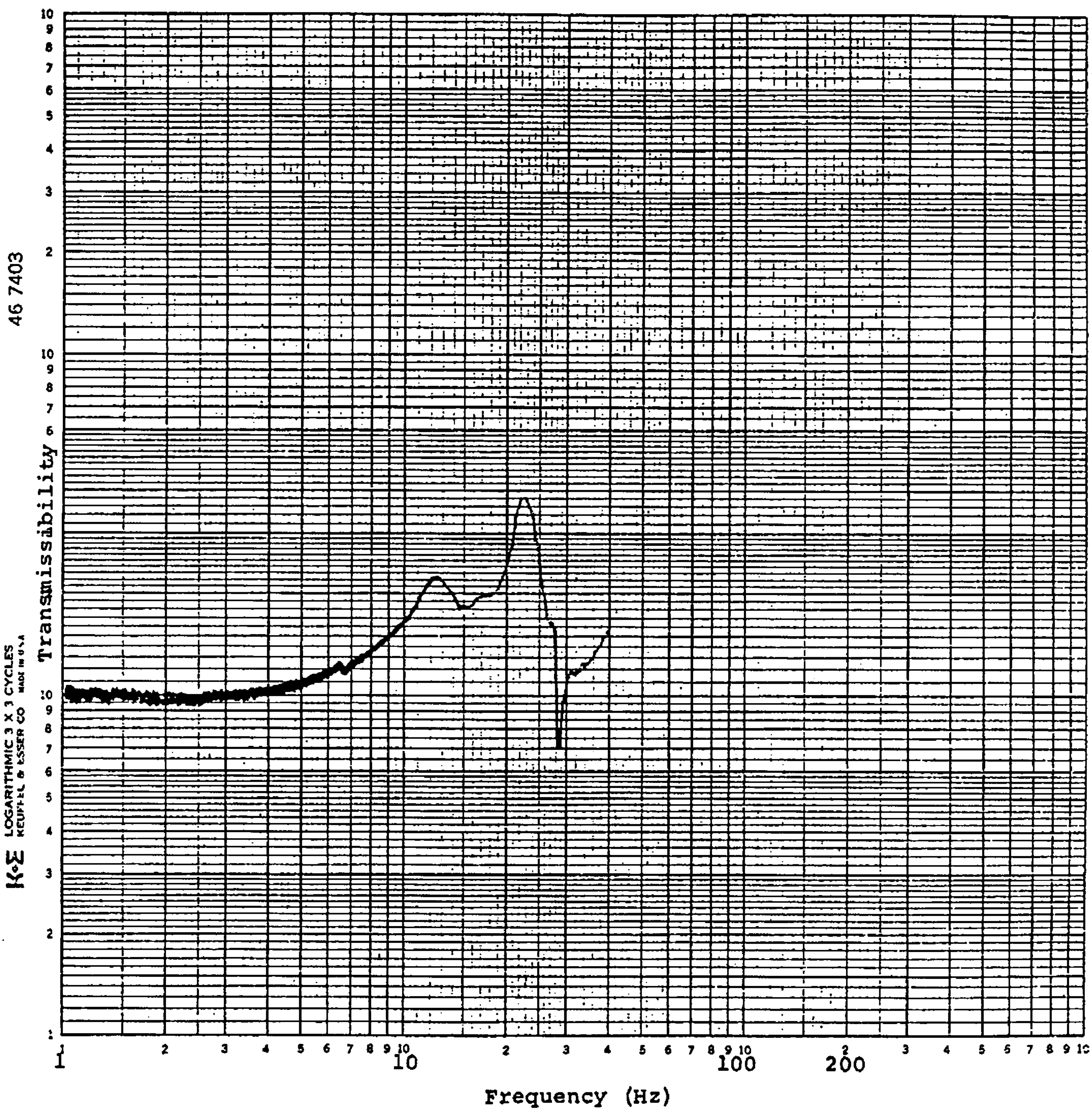
AXIS F-B/VERT

ACCEL. NO. 4V ÷ NO. VCA

TEST RUN NO. 9

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



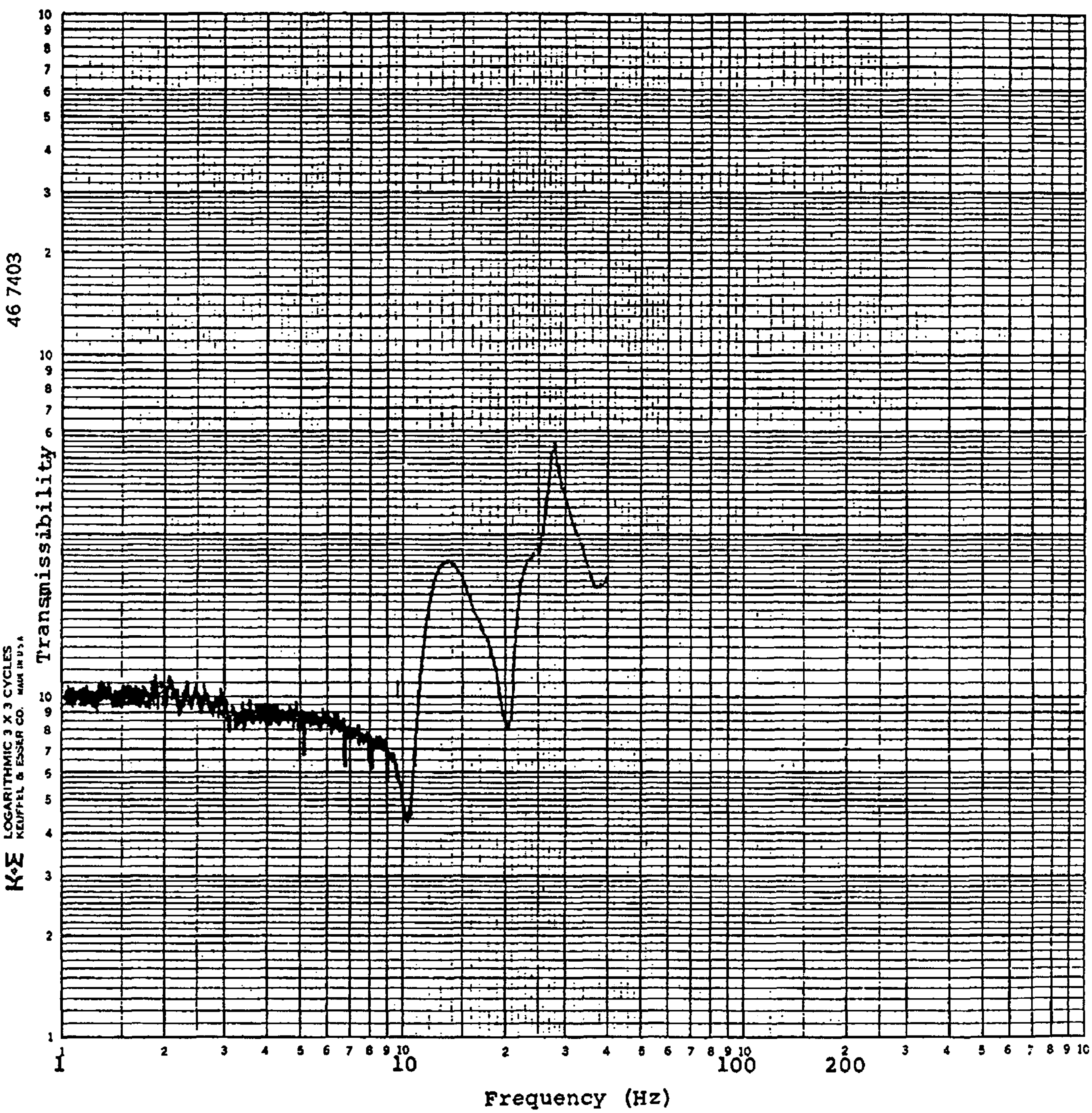
AXIS F-B/VERT

ACCEL. NO. 5 F-B ÷ NO. HCA

TEST RUN NO. 9

FULL SCALE TRANSMISSIBILITY

0.1 ☐ 1.0 ☐ 10 ☐ 100 ☒ 1000 ☐



AXIS F-B/VERT

ACCEL. NO. 6V ÷ NO. VCA

TEST RUN NO. 9

W 322

WYLE LABORATORIES
INSTRUMENTATION LOG SHEET

JOB NO. 43450

CUSTOMER C & D BATTERIES

LOG PAGE NO. 1 OF 4

TEST ENGINEER [illegible]

DATE	TIME	REMARKS (Include Run Number, Part Changes, Shift Changes and all other pertinent data)
16 NOV 76		SET-UP TO RECORD 2 CONTROL AND 6 RESPONSE ACCELEROMETERS
		ON TAPE AND OSCILLOGRAPH
		SET-UP TO RECORD ELECTRICAL MONITORS ON OSCILLOGRAPH
		RECORD CALIBRATION SIGNAL 1VPK 100HZ ON TAPE
		TAPE START 0000' END 0100'
		MOUNTED SPECIMENS IN THE S-S/VERT. AXIS
	1300	RUN#1, SINE SWEEP 1-40HZ 0.26 HORIZ 0.16 VERT S-S/VERT. AXIS
		TAPE START 0100' END 0525
	1325	RUN#2, MULTI-FREQUENCY RANDOM < ½ SSE S-S/VERT. AXIS
		TAPE START 0525' END 0560'
	1330	RUN#3, MULTI-FREQUENCY RANDOM ½ SSE S-S/VERT. AXIS
		TAPE START 0560' END 0600'

W 322

WYLE LABORATORIES
INSTRUMENTATION LOG SHEET

JOB NO. 43450 LOG PAGE NO. 2 OF 4

CUSTOMER C&D BATTERIES TEST ENGINEER [illegible]

DATE	TIME	REMARKS (Include Run Number, Part Changes, Shift Changes and all other pertinent data)
16 NOV 76	1337	Run #4 MULTI-FREQUENCY RANDOM ½ SSE S.S/VERT AXIS
		TAPE START 0600' END. 0635'
	1343	RUN #5 MULTI-FREQUENCY RANDOM ½ SSE S.S/VERT AXIS
		TAPE START 0635' END 0670'
	1346	RUN #6 MULTI-FREQUENCY RANDOM ½ SSE S.S/VERT AXIS
		TAPE START 0670' END 0700'
	1350	RUN #7 MULTI-FREQUENCY RANDOM ½ SSE S.S/VERT AXIS
		TAPE START 0700' END 0740'
	1402	RUN #8 MULTI-FREQUENCY RANDOM SSE S.S/VERT AXIS
		TAPE START 0740' END 0780'
		BATTERY #5 CRACKED DURING RUN #8
		REMOVED BATTERIES 1, 4 & 5, INSTALLED BATTERIES 14, 15

W 322

WYLE LABORATORIES
INSTRUMENTATION LOG SHEET

JOB NO. 43450 LOG PAGE NO. 3 OF 4

CUSTOMER C&D BATTERIES TEST ENGINEER [illegible]

DATE	TIME	REMARKS (Include Run Number, Part Changes, Shift Changes and all other pertinent data)
16 NOV 76		ROTATED SPECIMENS 90° TO THE F-B&VERT. AXIS
	1730	RUN#9, SINE SWEEP 1-40HZ 0.2G HORIZ 0.1G VERT F-B/VERT. AXIS
		TAPE START 0780' END 1215'
	1744	RUN#10, MULTI-FREQUENCY RANDOM 1/2 SSE F-B/VERT. AXIS
		TAPE START 1215' END 1250'
	1750	RUN#11, MULTI-FREQUENCY RANDOM 1/2 SSE F-B/VERT. AXIS
		TAPE START 1250' END 1285'
	1753	RUN#12, MULTI-FREQUENCY RANDOM 1/2 SSE F-B/VERT. AXIS
		TAPE START 1285' END 1320'
	1755	RUN#13, MULTI-FREQUENCY RANDOM 1/2 SSE F-B/VERT. AXIS
		TAPE START 1320' END 1355'

W 322

WYLE LABORATORIES
INSTRUMENTATION LOG SHEET

JOB NO. 43450

LOG PAGE NO. 4 OF 4

CUSTOMER C&D BATTERIES

TEST ENGINEER [signature]

DATE	TIME	REMARKS (Include Run Number, Part Changes, Shift Changes and all other pertinent data)
16 NOV 76	1759	RUN# 14 MULTI-FREQUENCY RANDOM ½ SSE F.B/VERT AXIS
		TAPE START 1355' END 1395'
	1804	RUN# 15 MULTI-FREQUENCY RANDOM SSE F.B/VERT AXIS
		TAPE START 1395' END 1435'

INSTRUMENTATION EQUIPMENT SHEET

Date 16 NOV 76 Job No. 43450 Test Area PIT # 1

Technician FROST Customer C&D BATTERIES Type Test SEISMIC

No.	Instrument	Manufacturer	Model No.	Serial No.	Wyle or Gov't No.	Range	Accuracy	Calibration On	Calibration Due
1	ACCELEROMETER	ENDEVCO	2272	EQ 21	96148	1000g	±5%	9-15-76	12-15-76
2	ACCELEROMETER	ENDEVCO	2272	EP 49	96146	1000g	±5%	9-15-76	12-15-76
3	ACCELEROMETER	ENDEVCO	2272	EQ 36	96150	1000g	±5%	9-15-76	12-15-76
4	ACCELEROMETER	ENDEVCO	2272	EQ 73	96157	1000g	±5%	9-15-76	12-15-76
5	ACCELEROMETER	ENDEVCO	2272	EQ 38	96151	1000g	±5%	9-15-76	12-15-76
6	ACCELEROMETER	ENDEVCO	2272	NA67	F1432	1000g	±5%	9-3-76	12-3-76
7	ACCELEROMETER	ENDEVCO	2219	AB84	96190	500g	±5%	8-31-76	12-1-76
8	ACCELEROMETER	ENDEVCO	2219	AB92	96248	500g	±5%	8-31-76	12-1-76
9	CHARGE AMP	DYNAMICS	7302	—	1648	500g	±2%	7-8-76	1-8-77
10	CHARGE AMP	DYNAMICS	7302	—	1556	500g	±2%	7-8-76	1-8-77
11	CHARGE AMP	DYNAMICS	7302	—	1510	500g	±2%	7-8-76	1-8-77
12	CHARGE AMP	DYNAMICS	7302	—	1679	500g	±2%	7-8-76	1-8-77
13	CHARGE AMP	DYNAMICS	7302	—	1563	500g	±2%	7-8-76	1-8-77
14	CHARGE AMP	DYNAMICS	7302	—	1572	500g	±2%	7-8-76	1-8-77
15	CHARGE AMP	DYNAMICS	7302	—	1641	500g	±2%	7-8-76	1-8-77
16	CHARGE AMP	DYNAMICS	7302	—	1600	500g	±2%	7-8-76	1-8-77
17	OSCILLOSCOPE	TEKTRONIX	RM561	—	605F54	.02-10V/cm	±2%	9-9-76	12-9-76
18	VOLTMETER	B&K	2426	—	95492	300V	±2%	9-24-76	12-24-76

Instrument Test Engineer [signature] Checked & Received By Charles L. Adams

WH-1029

INSTRUMENTATION EQUIPMENT SHEET

Date 16 NOV 76 Job No. 43450 Test Area PIT #1

Technician FROST Customer C&D BATTERIES Type Test SEISMIC

No.	Instrument	Manufacturer	Model No.	Serial No.	Wyle or Gov't No.	Range	Accuracy	Calibration On	Calibration Due
19	DIGI-MARK	CHADWICK-H	423	—	97694	.1-1sec	±1CNT	11-10-76	2-10-77
20	TAPE RECORDER	B&H	CPR4010	—	96291	D.C. 2.5KHz	±2%	9-22-76	3-22-77
21	VISICORDER	HONEYWELL	1912	—	96273	2.5KHz	±4%	9-10-76	3-10-77
22	GALVO AMP	HONEYWELL	T6GA500	—	R-11	1:1	±2%	8-9-76	2-9-77
23	GALVO AMP	HONEYWELL	T6GA500	—	96259	1:1	±2%	7-19-76	1-19-77
24	LOG CONVERTER	SPEC DYNAMICS	SD112-1	—	96145	80db	±2%	10-22-76	1-22-77
25	CARRIER GENERATOR	SPEC DYNAMICS	SD 1010	—	80557	40 db	±1%	10-22-76	1-22-77
26	TRACKING FILTER	SPEC DYNAMICS	SD1012	—	81609	40db	±.5db	10-22-76	1-22-77
27	X-Y RECORDER	HP	7004B	—	95202	.6mv-10v/in	±.2%	10-14-76	1-14-77
28	X-Y RECORDER	H.P.	7044A	—	95377	.5mv-10v/in	±.2%	8-18-76	11-18-76
29	SPECTRUM SYNTHESIZER	M-RAD	1975	—	95363	.5-100Hz	±4%	8-23-76	11-23-76
30	SPECTRUM ANALYZER	M-RAD	2825	—	95354	.5-10KHz	±2%	8-23-76	11-23-76
31	SERVO MONITOR	SPEC. DYNAMICS	SD 105	—	95358	1000g	±4%	10-20-76	1-20-77
32	SERVO MONITOR	SPEC DYNAMICS	SD105	—	95359	1000g	±4%	10-20-76	1-20-77
33	SWEEP OSCILLATOR	SPEC DYNAMICS	SD 104	—	95360	.5-50KHz	±2%	10-20-76	1-20-77
34	POWER SUPPLY	DRESSEN	27144	—	95174	0-15vdc	±.1%	7-29-76	1-29-77
35	POWER SUPPLY	KEPCO	SM160-2	—	97872	0-160vdc	±.1%	10-27-76	1-27-77

Instrument Test Engineer [signature] Checked & Received By Charles L. Adams

WH-1029

Page No. 53
Report No. 43450-1

TEST PROCEDURE

WYLE LABORATORIES
SCIENTIFIC SERVICES AND SYSTEMS GROUP
P. O. BOX 1008 • HUNTSVILLE, ALABAMA 35807
TWX (810) 726-2225 • TELEPHONE (205) 837-4411

TEST PROCEDURE NO. 541/4212/ES

DATE: September 2, 1975

SEISMIC TEST PLAN

FOR

BATTERY RACK
AND
BATTERIES

FOR

C&D BATTERIES
PLYMOUTH MEETING, PENNSYLVANIA

APPROVED BY: ____________________
FOR: ____________________

APPROVED BY: ____________________
FOR: ____________________

APPROVED BY: Herschel Jordan
FOR: L.E.F.

APPROVED BY
PROJECT MANAGER: ____________________

APPROVED BY
QUALITY ENGINEER: ____________________

PREPARED BY
PROJECT ENGINEER: Charles L. Adams

REVISIONS

FORM 1054-1 Rev. 4/74

REV. NO.	DATE	PAGES AFFECTED	BY	APP'L.	DESCRIPTION OF CHANGES
A	11/16/76	2	CA	HJ	Para. 2.2 - Sweep rate changed from
					one to one-half octave per minute.
A	11/16/76	2	CA	HJ	Para. 2.3 - DBE RRS substituted for
					SSE.
A	11/16/76	8	CA	HJ	Added Figure 3.
A	11/16/76	2	CA	HJ	Para. 1.1 - Deleted mention of
					number of batteries

1.0 MOUNTING

1.1 Specimen Orientation A

A Battery Rack and Batteries, as shown in Figure 1, hereinafter called the specimen, will be placed on the Wyle Multiaxis Simulator Table. The specimen will be oriented such that its longitudinal axis will be co-linear with the longitudinal axis of the test table. For the second axis of test, the specimen will be rotated 90 degrees in the horizontal plane and the specified sequence of tests repeated.

1.2 Specimen Tie-Down

The mounting hole pattern in the base of the Battery Rack will be transferred to the test table. These holes will then be drilled in the test table and the specimen will be attached using commercially-available bolts, nuts and washers. A description of the mounting bolts will be included in the test report. The tests will be conducted with the specimen sitting in its actual gravitational orientation. The mounting will simulate as closely as possible the actual in-service mounting.

2.0 EXCITATION

2.1 Simultaneous Biaxial Excitation

Each horizontal axis will be excited separately but each one will be excited simultaneously with the vertical axis (longitudinal simultaneous with vertical, then lateral simultaneous with vertical). The horizontal and vertical input acceleration levels will be phase incoherent during the multi-frequency tests.

2.2 Exploratory Search A

A low-level (approximately 0.2 g horizontally and 0.1 g vertically) biaxial sine sweep from 1 Hz to 40 Hz will be performed to establish major resonances. The sweep rate will be one-half octave per minute.

2.3 Multi-Frequency Tests A

The specimen will be subjected to simultaneous horizontal and vertical input of random motion consisting of frequencies spaced one-third octave apart over the frequency range of 1 Hz to 40 Hz. The amplitude of each one-third octave frequency will be independently adjusted in each axis until the Test Response Spectra (TRS) envelope the Required Response Spectra (RRS). The composite spectra as shown in Figures 2 and 3 will be used as the DBE RRS.

2.3.1 One-Half-Level DBE (OBE) Tests A

Five (5) one-half-level DBE (OBE) tests will be performed in each test axis to simulate seismic aging. Duration of the one-half-level DBE (OBE) tests will be 30 sec nds. The one-half-level tests will be one-half the level of Figure 2.

2.3.2 DBE Tests A

One (1) DBE test will be performed in each test axis. Duration of the DBE tests will be 30 seconds. The DBE RRS are shown in Figures 2 and 3.

3.0 INSTRUMENTATION

3.1 Excitation Control

Control accelerometers will be mounted on the table at locations near the driving point for the horizontal and each vertical actuator. Additionally, one vertically-oriented accelerometer will be located at the center of the table for verification purposes.

3.2 Specimen Response

Six specimen-mounted uniaxial piezo-electric accelerometers will be located on the specimen under test. The placement of the accelerometers will be at the discretion of the C&D Batteries Technical Representative. An FM tape and oscillograph recorder will provide a record of each accelerometer response. A response spectrum plot from each specimen response accelerometer from the full-level test in each orientation will be analyzed at a damping of 1%. Transmissibility plots of the exploratory search will be provided in the test report.

3.3 Electrical Load

A 20 ampere resistive load will be provided for the Batteries prior to, during and after the seismic test.

3.4 Electrical Monitoring

One channel of electrical monitoring for the specimen will be recorded on an oscillograph recorder during the Seismic Simulation Test Program. This channel will be used to monitor the nominal 32 VDC battery voltage.

3.5 Assembly and Disassembly of Specimen

The Battery Rack will be assembled by Wyle personnel and the Batteries installed in the assembled rack for the test. Subsequent to completion of tests, the Batteries and rack will be disassembled and packed for shipment.

4.0 IN-PROCESS INSPECTION

The records will be checked for equality of performance after each test.

The specimen will be examined for possible damage following all violent tests such as at a severe structural resonance. A physical tightening of hardware will be performed after such tests.

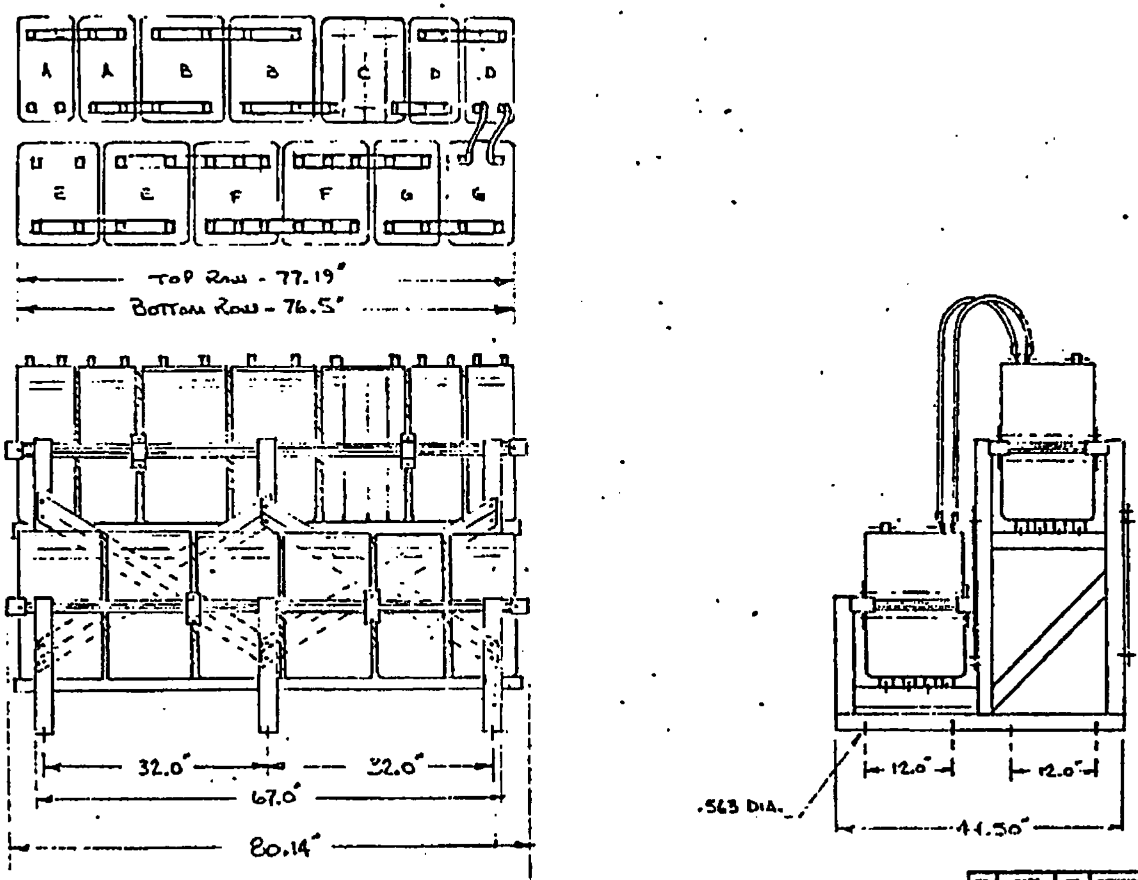
All important vibration effects will be logged.

Photographs will be taken of any noticeable physical damage that may occur and of all mounted accelerometers.

5.0 REPORT

Ten copies of a certification-type report will be issued subsequent to completion of testing. This report will be signed by a Registered Professional Engineer and will summarize the maximum g levels, natural frequencies, response spectrum plots of the control and specimen accelerometers, details and recommendations concerning deficiencies and repairs, photographs of test setups, accelerometers, failures, etc. The report will also contain a list of test equipment used, calibrations, and instrumentation log sheets.

CELL A : LC-21
B : LC-29
C : 4LCY-11
D : LC-15
E : CF-1690
F : LCY-29
G : LC-25



RACK WEIGHT: 450 LBS
CELL WEIGHT: 2211 LBS TOP ROW
2222 LBS BOTTOM ROW
4883 LBS TOTAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
TOLERANCES ON:

FRACTIONS	DECIMALS			ANGLES
	X	XX	XXX	

MATERIAL:

PER: SPEC.:

NO.	DATE	BY	REVISION

C&D BATTERIES

an Eltra company

TWO STEP RACK AND TEST CELLS FOR SEISMIC QUALIFICATION

DRAWN | APPROVED
CHECKED | DRAWING NO. SK-27
DATE |
SCALE NONE | SHEET OF

FIGURE 1

Composite Horizontal DBE
1% Damping

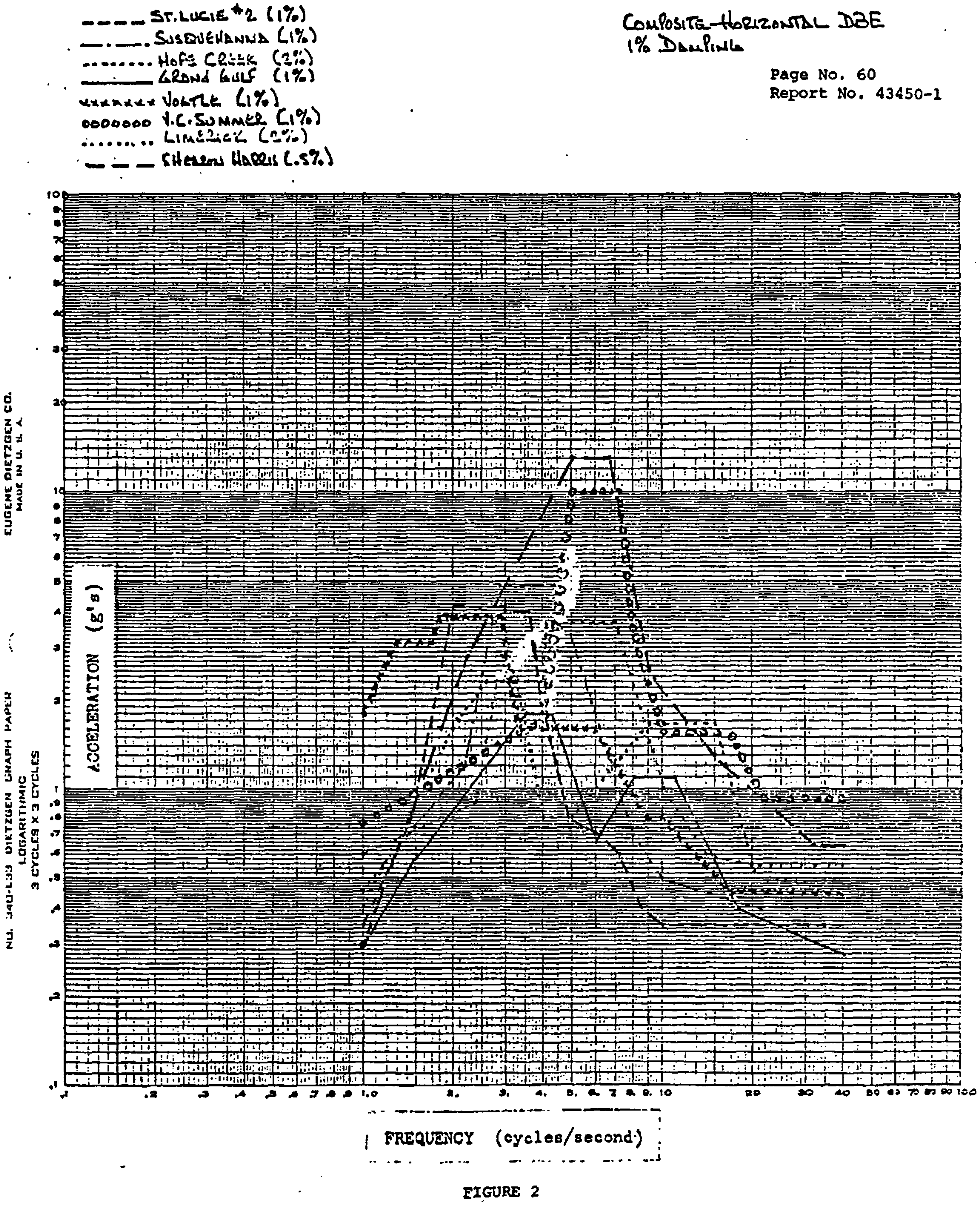


FIGURE 2

St. Lucie #2 (1%)
Susquehanna (1%)
Hope Creek (2%)
Grand Gulf (1%)
Vogtle (1%)
V.C. Summer (1%)
Limerick (2%)
Shearon Harris (.5%)

COMPOSITE VERTICAL DBE
DAMPING 1%

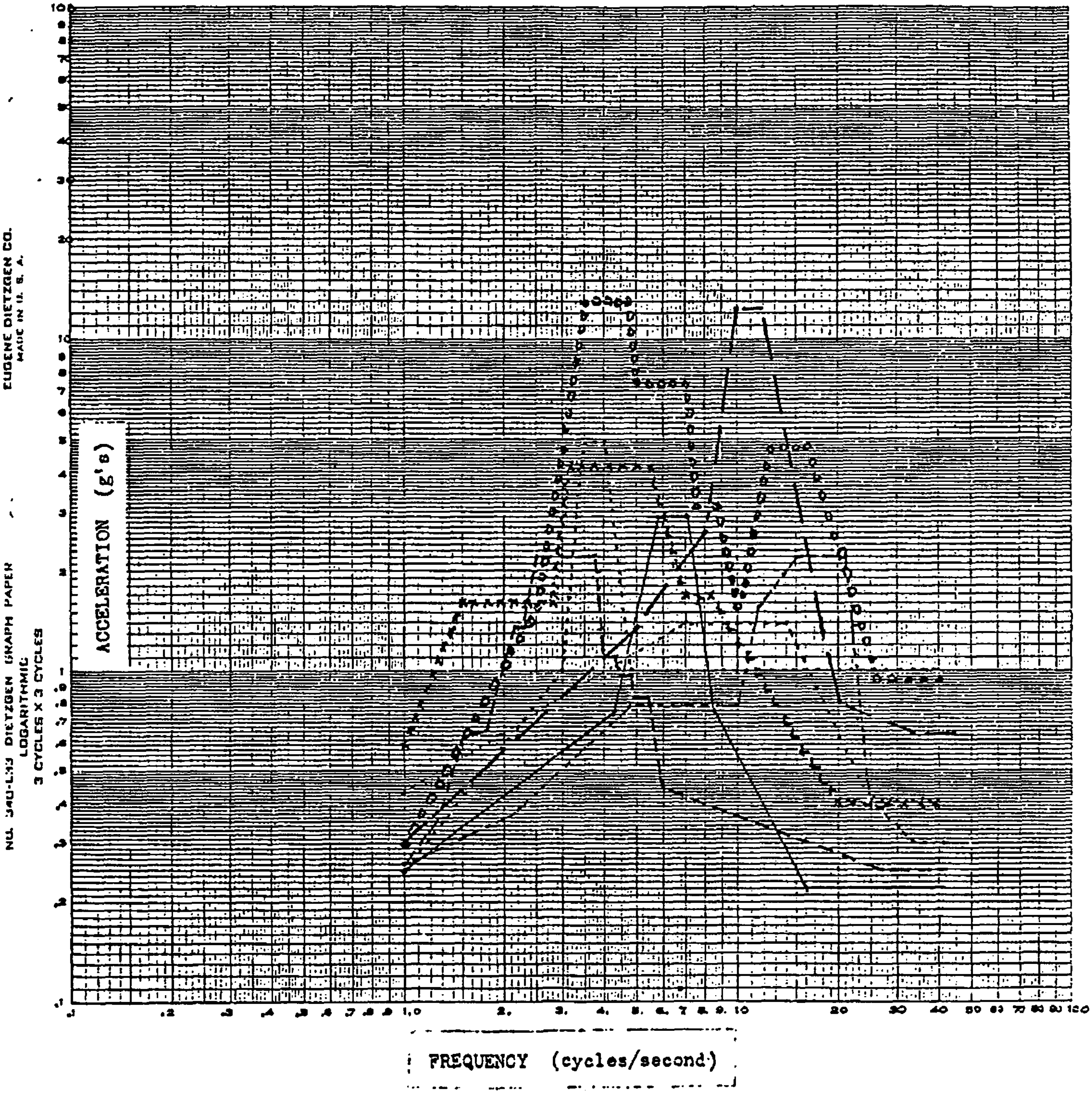


FIGURE 3

C&D "L" Cell Nuclear Qualification Justification

The following engineering analysis summary details the type testing completed by C&D Technologies and it's applicability as justification for qualifying Class 1E batteries and racks per IEEE Std 535-1979, IEEE Std 535-1986, and/or IEEE Std 535-2006. C&D completed type testing of their products prior to the official release of IEEE Std 535-1979 which was developed to provide specific methods and type test procedures for lead acid batteries in adherence to IEEE Std 323-1974. All of the testing completed by C&D was conducted per IEEE Std 323-1974, IEEE Std 344-1975, and IEEE Std 450-1975 specifications.

C&D Technologies has conducted a comprehensive review of all the code revisions that have been released to IEEE standards 323,344, 450, and 535 since conducting their original qualification type testing in the 1970's. This review was undertaken to identify what impact, if any, these revisions to the individual codes may have on present day Class 1E qualifications or the type testing that was completed.

Original Qualification Background:

C&D Technologies originally conducted their nuclear qualification type testing to IEEE Stds 323-1974, 344-1975, and a draft version (Draft 8) of IEEE Std 535 (pre-dated first issuance in 1979). All cell electrical testing was completed per IEEE Std 450-1975. The primary "LC" model qualification testing was conducted under Wyle Labs report number 43450-1 and later seismic supporting testing of additional artificially aged cells was conducted under Wyle Labs report number 44467-1.

Wyle Labs test number 43450-1 included of a variety of "LC" cell models (see Table 1 below) including 25-year old naturally aged cells as well as 20-year old artificially aged cells.

Table 1: "LC" Qualification Cells Wyle Test 43450-1

CELL TYPE	AGED?	WGT QTY	LGT LBS	WIDTH IN.	HGT IN.	LINEAR IN.	WT/IN.	8 HR AMP-HR	JAR MATL
4LCY-11	No	1	450	15.00	14.13	22.75	30.00	680	SAN
LC-15	No	2	210	7.63	14.13	22.63	27.52	1050	PC
LC-21	20 Yr	2	270	8.88	14.13	22.63	30.40	1500	PC
LC-25	No	2	325	10.63	14.13	22.63	30.57	1800	SAN
LCU-27	No	2	341	10.63	14.13	22.63	32.08	1950	SAN
LC-29	No	2	367	13.19	14.13	22.63	27.82	2030	PC
LCY-39	No	2	438	13.19	14.13	22.63	33.21	2400	PC
CF-1440	25 Yr	2	320	13.19	14.13	22.63	24.26	1440	PC

Wyle Labs conducted the type testing per IEEE Stds 323-1974 and 344-1975. C&D conducted the electrical testing per IEEE Std 450-1975.

Code Update IEEE Std 535-1979

C&D's type testing was carried out per the qualification procedures set forth in IEEE Std 535-1979 with two minor deviations, but they do not invalidate the qualification of C&D's "LC" model cells. Justification of these deviations is provided below.

> **(a)** Section 8.3.1.1 (1), and 8.3.1.4 of IEEE-535 requires pre-seismic and post-seismic capacity tests be performed at the cells' 3 hour discharge rate to 1.75 average volts per cell. The test cells from all the qualification programs were tested at 1 hour and 8 hour rates. This test envelopes the requirement of IEEE-535 because the 8 hour test exceeds the 3 hour test depth of discharge, and the one hour test exceeds the discharge current of a 3 hour test. These tests stressed the cells' electrochemical efficiency, or the conductivity of current carrying members to a greater extent than a 3-hour test. Alternatively, IEEE Std 535-1979 (para 8.3.1.1 (1)) allows the discharge test performed after the aging portion of the test to be substituted for the pre-seismic capacity test.
>
> **(b)** Section 8.3.1.1 (2) of IEEE-535 requires a fixed discharge load during seismic testing of approximately 2% of the battery's 3 hour discharge rate. However, the Standard also allows a higher discharge current to be used. The load on the "LC" type test batteries was 20 amps which is greater than 2% of the 3 hour rate for the largest "LC" cell employed in the test. The discharge rate of 20 amps used during the seismic qualification exceeds the requirements of IEEE Std 535-1979.

Code Updates IEEE Std 535-1986

There were minimal changes made to IEEE Std 535-1979 in the 1986 release. Most of the changes involved updating IEEE Std 323 references from 1974 to 1983 editions and IEEE Std 450 from 1975 to 1980 version. The other significant changes were allowing individual components to be replaced during the aging procedures (para 8.2) and the specification of 50-100mV positive plate potentials (para 8.2.2) during artificial aging. C&D adhered to the 50-100mV positive plate potentials during the aging of our original qualification cells and was integral to the incorporation of this requirement, and the replacement of individual components clause, into the 1986 code revision.

Referenced within the IEEE Std 535-1986 code was IEEE Std 323-1983 and IEEE Std 450-1980. The changes incorporated within IEEE Std 323-1983 were made to clarify its requirements and imposed no additional requirements for qualifying Class 1E equipment. The changes incorporated into IEEE Std 450-1980 were also minimal in their effect to our type testing. The changes were primarily related to correction factors and determining battery capacity. C&D conducted all baseline, pre-seismic, and post-seismic testing in an identical manner for the duration of the type test to accurately reflect any capacity losses. While IEEE Std 450 is referenced within the IEEE Std 535 documents, it has no impact on the actual Class 1E qualification.

Code Updates IEEE Std 535-2006

There were minimal changes made to IEEE Std 535-1986 in the 2006 release. Most of the changes involved updating IEEE Std 323 references from 1983 to 2003, IEEE Std 344 from 1975 to 2005, and IEEE Std 450 from 1980 to the 2002 version.

Several sections were slightly rewritten to add additional clarity but overall qualification requirements remained unchanged. Some of the additional requirements that were added included:

- Sect 4: Inclusion of 1.25 aging factor per IEEE Std 485-1997 and requirement that each jar size must be tested
- Sect 5.4 c): Added entire section regarding extension of qualified life (not applicable to C&D qualification reports)
- Sect 8.2.2: Changed recommended discharge from 3h rate to 1.75vpc to 2h with allowance for 2-4h discharge rate. However, para 8.3.1.1 (a) allows the discharge test performed after aging portion of test to be substituted for pre-seismic capacity test. Once again, C&D tested at the 1h and 8h rates which envelope the requirements of this section.

Referenced within the IEEE Std 535-2006 code was IEEE Std 323-2003, IEEE 344-2004, and IEEE Std 450-2002. The changes incorporated within IEEE Std 323-2003 that could impact battery and rack qualification included elimination of the need for qualified life in mild environments for equipment with no significant aging mechanisms, updated test margin values, and the elimination of radiation testing for mild environments. The issue of margin incorporation is addressed within the individual Seismic and Environmental reports prepared for each plant.

IEEE Std 535-2006 updates the reference of IEEE Std 344 from 1975 to 2005 (issue date, but code title is 2004). The code revisions to IEEE Std 535 never included a reference to the IEEE Std 344 issued in 1987. Both the IEEE Std 344-1987 and 2004 releases were developed to expand and clarify and did not include any additional qualification requirements.

The changes incorporated into IEEE Std 450-2002 were also minimal in their effect to our type testing. The changes were primarily related to correction factors and determining battery capacity. C&D conducted all baseline, pre-seismic, and post-seismic testing in an identical manner for the duration of the type test to accurately reflect any capacity losses. While IEEE Std 450 is referenced within the IEEE Std 535 documents, it has no impact on the actual Class 1E qualification.

Summary

The original type testing completed in the 1970's is still valid, and directly applicable, as the basis of Class 1E qualifications per any version of IEEE Std 535 for the years 1979 through 2006. Additionally, the code changes implemented to IEEE Stds 323, 344, and 450 since the 1970's were made to increase the qualification options and had no impact on the type testing previously conducted by C&D.

Drew Heimer
Director, Product Development

C&D "K" Cell Nuclear Qualification Justification

The following engineering analysis summary details the type testing completed by C&D Technologies and it's applicability as justification for qualifying Class 1E batteries and racks per IEEE Std 535-1979, IEEE Std 535-1986, and/or IEEE Std 535-2006. C&D completed type testing of their products prior to the official release of IEEE Std 535-1979 which was developed to provide specific methods and type test procedures for lead acid batteries in adherence to IEEE Std 323-1974. All of the testing completed by C&D was conducted per IEEE Std 323-1974, IEEE Std 344-1975, and IEEE Std 450-1975 specifications.

C&D Technologies has conducted a comprehensive review of all the code revisions that have been released to IEEE standards 323,344, 450, and 535 since conducting their original qualification type testing in the 1970's. This review was undertaken to identify what impact, if any, these revisions to the individual codes may have on present day Class 1E qualifications or the type testing that was completed.

Original Qualification Background:

C&D Technologies originally conducted their nuclear qualification type testing to IEEE Stds 323-1974, 344-1975, and a draft version (Draft 8) of IEEE Std 535 (pre-dated first issuance in 1979). All cell electrical testing was completed per IEEE Std 450-1975. The primary "KC" model qualification testing was conducted under Wyle Labs report numbers 44466-1 and 43291-1.

Wyle Labs test report numbers 44466-1 and 43291-1 included of a variety of 20-year aged "KC" cell models (see Table 1 below).

TABLE 1: "KC" SEISMIC TEST CELLS

CELL TYPE	AGED?	WGT QTY	LGT LBS	WIDTH IN.	HGT IN.	LINEAR IN.	WT/IN.	3 HR AMP-HR	JAR MATL
			(WYLE Test No. 43291-1)						
KC-19	20 YR	2	143	8.53	10.44	18.25	16.67	586	PC
KCY-23	No	3	156	8.53	10.44	18.25	18.29	624	PC
KCY-25	No	3	165	8.53	10.44	18.25	19.34	675	PC
			(WYLE Test No. 44466-1)						
KC-9	20 YR	3	73	4.63	10.44	18.25	15.77	260	PC
KC-13	20 YR	2	97	5.59	10.44	18.25	17.35	390	PC
KC-17	20 YR	2	134	8.53	10.44	18.25	15.71	521	PC
KC-21	20 YR	3	152	8.53	10.44	18.25	17.82	650	PC

Wyle Labs conducted the type testing per IEEE Stds 323-1974 and 344-1975. C&D conducted the electrical testing per IEEE Std 450-1975.

Code Update IEEE Std 535-1979

C&D's type testing was carried out per the qualification procedures set forth in IEEE Std 535-1979 with two minor deviations, but they do not invalidate the qualification of C&D's "KC" model cells. Justification of these deviations is provided below.

(a) Section 8.3.1.1 (1), and 8.3.1.4 of IEEE-535 requires pre-seismic and post-seismic capacity tests be performed at the cells' 3 hour discharge rate to 1.75 average volts per cell. The test cells from all the qualification programs were tested at 1 hour and 4 hour rates. This test envelopes the requirement of IEEE-535 because the 4 hour test exceeds the 3 hour test depth of discharge, and the one hour test exceeds the discharge current of a 3 hour test. These tests stressed the cells' electrochemical efficiency, or the conductivity of current carrying members to a greater extent than a 3-hour test. Alternatively, IEEE Std 535-1979 (para 8.3.1.1 (1)) allows the discharge test performed after the aging portion of the test to be substituted for the pre-seismic capacity test.

(b) Section 8.3.1.1 (2) of IEEE-535 requires a fixed discharge load during seismic testing of approximately 2% of the battery's 3 hour discharge rate. However, the Standard also allows a higher discharge current to be used. The load on the "KC" type test batteries was 20 amps which is greater than 2% of the 3 hour rate for the largest "KC" cell employed in the test. The discharge rate of 20 amps used during the seismic qualification exceeds the requirements of IEEE Std 535-1979.

Code Updates IEEE Std 535-1986

There were minimal changes made to IEEE Std 535-1979 in the 1986 release. Most of the changes involved updating IEEE Std 323 references from 1974 to 1983 editions and IEEE Std 450 from 1975 to 1980 version. The other significant changes were allowing individual components to be replaced during the aging procedures (para 8.2) and the specification of 50-100mV positive plate potentials (para 8.2.2) during artificial aging. C&D adhered to the 50-100mV positive plate potentials during the aging of our original qualification cells and was integral to the incorporation of this requirement, and the replacement of individual components clause, into the 1986 code revision.

Referenced within the IEEE Std 535-1986 code was IEEE Std 323-1983 and IEEE Std 450-1980. The changes incorporated within IEEE Std 323-1983 were made to clarify its requirements and imposed no additional requirements for qualifying Class 1E equipment. The changes incorporated into IEEE Std 450-1980 were also minimal in their effect to our type testing. The changes were primarily related to correction factors and determining battery capacity. C&D conducted all baseline, pre-seismic, and post-seismic testing in an identical manner for the duration of the type test to accurately reflect any capacity losses. While IEEE Std 450 is referenced within the IEEE Std 535 documents, it has no impact on the actual Class 1E qualification.

Code Updates IEEE Std 535-2006

There were minimal changes made to IEEE Std 535-1986 in the 2006 release. Most of the changes involved updating IEEE Std 323 references from 1983 to 2003, IEEE Std 344 from 1975 to 2005, and IEEE Std 450 from 1980 to the 2002 version.

Several sections were slightly rewritten to add additional clarity but overall qualification requirements remained unchanged. Some of the additional requirements that were added included:

- Sect 4: Inclusion of 1.25 aging factor per IEEE Std 485-1997 and requirement that each jar size must be tested
- Sect 5.4 c): Added entire section regarding extension of qualified life (not applicable to C&D qualification reports)
- Sect 8.2.2: Changed recommended discharge from 3h rate to 1.75vpc to 2h with allowance for 2-4h discharge rate. However, para 8.3.1.1 (a) allows the discharge test performed after aging portion of test to be substituted for pre-seismic capacity test. Once again, C&D tested at the 1h and 4h rates which envelope the requirements of this section.

Referenced within the IEEE Std 535-2006 code was IEEE Std 323-2003, IEEE 344-2004, and IEEE Std 450-2002. The changes incorporated within IEEE Std 323-2003 that could impact battery and rack qualification included elimination of the need for qualified life in mild environments for equipment with no significant aging mechanisms, updated test margin values, and the elimination of radiation testing for mild environments. The issue of margin incorporation is addressed within the individual Seismic and Environmental reports prepared for each plant.

IEEE Std 535-2006 updates the reference of IEEE Std 344 from 1975 to 2005 (issue date, but code title is 2004). The code revisions to IEEE Std 535 never included a reference to the IEEE Std 344 issued in 1987. Both the IEEE Std 344-1987 and 2004 releases were developed to expand and clarify and did not include any additional qualification requirements.

The changes incorporated into IEEE Std 450-2002 were also minimal in their effect to our type testing. The changes were primarily related to correction factors and determining battery capacity. C&D conducted all baseline, pre-seismic, and post-seismic testing in an identical manner for the duration of the type test to accurately reflect any capacity losses. While IEEE Std 450 is referenced within the IEEE Std 535 documents, it has no impact on the actual Class 1E qualification.

Summary

The original type testing completed in the 1970's is still valid, and directly applicable, as the basis of Class 1E qualifications per any version of IEEE Std 535 for the years 1979 through 2006. Additionally, the code changes implemented to IEEE Stds 323, 344, and 450 since the 1970's were made to increase the qualification options and had no impact on the type testing previously conducted by C&D.

Drew Heimer
Director, Product Development